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UNDERSTANDING AND PREDICTING HUMAN BEHAVIOUR IN MARITIME EMERGENCIES

OTERO FINITI

A thesis submitted to the University of Huddersfield

in partial fulfilment of the requirements

for the degree of Doctor of Philosophy

JUNE 2021

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Abstract

Maritime disasters can result in devastating loss of life. In order to mitigate such loss, it is necessary to optimise the efficacy of evacuation procedures. Previous research on maritime disasters and the behaviour observed during evacuation is limited. This is mainly due to issues involving the collection of sufficient reliable data. Human behaviour is a complex phenomenon variously affected by experience, emotions, interactions and environment. These factors are further modulated by the life-threatening nature of uniquely evolving disasters. Currently, computational evacuation models fail to consider passengers as sentient, psychological agents. Some have shown success in the prediction of actions undertaken.

This thesis describes three interlinked studies intended to crystallise a methodological approach for effective future research into disaster evacuations. The first study was a replication of a previous study of the Costa Concordia disaster. Behavioural Sequence Analysis was conducted on data collected from a new sample of survivors. Statistically significant correlations were found which indicated the reliability of the method of data collection. These data were then broken down by gender, age, companions, and experience in order to detect intra-cohort differences. Analysis of routes and transitions in decomposition diagrams detected differences between sub-cohorts. However, existing psychological literature was unable to offer consistent, persuasive explanations for certain detected phenomena.

The second study involved the recreation of the first study using the ‘Talk-Through’ method. This method is potentially valuable for the creation of reliable imagined data, which mirrors real-life experiences. The third study involved an in-depth comparison of the data extracted by each method. This filled a specifically noted gap in knowledge concerning the ecological validity of the ‘Talk-Through’ method. It was anticipated that the results of the two methods would be comparable. Indeed, correlation analysis provided evidence for the validity of the talk-through method with respect to the number of acts and transitions reported in each condition.

In order to accelerate evacuation research, refinements to data-collection and analysis were proposed. By taking control of the storytelling, more controlled and comparable data may be produced which focus on choices made at each phase during a complete sequence of evacuation. This would create data more appropriate for computer modelling and more capable of quantitatively evaluating choices. Understanding motivations is critical to the communication of effective and authoritative instruction. By redirecting psychological research towards this goal, persuasive evidence may be produced to guide and inform the implementation and execution of emergency evacuation procedures.

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Chapter One: Understanding and Predicting Human Behaviour in Maritime Emergencies

1.1 Background

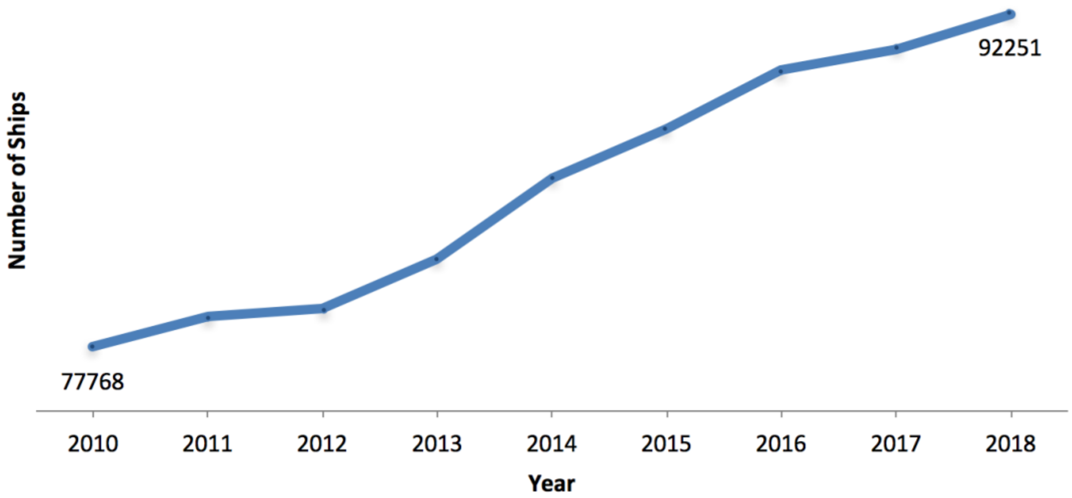
Maritime transport has existed for centuries. Over the past two hundred years, the size and range of ships has increased substantially (Dickinson & Vladimir, 1997; Yeoman & McMahon-Beattie, 2019). Over time, their function has diversified from purely transportation towards the leisure market (Koteski et al., 2016; Radogna, 1982; Yeoman & McMahon-Beattie, 2019). Consequently, cruise ship companies were founded to cater for this demand (Armonsky, 2012; Koteski et al., 2016). Mark Twain described a cruise as *a picnic on a giant scale* (Dickinson & Vladimir, 1997). Since then, the scale has only increased.

Advances in maritime technology led to the construction of the so-called "floating buildings" such as the Titanic (Biehn, 2006). The Titanic was designed to be the largest and most luxurious ocean liner the world had ever seen (Dickinson & Vladimir, 1997). The price to pay, however, was safety. At the time, maritime rules compelled companies to equip their ships with a certain number of lifeboats based on their tonnage. The Titanic carried sixteen lifeboats, more than the regulated standards, yet only enough to evacuate from the ship approximately half of its passengers (Frey, et al., 2012). In 1912 the Titanic set sail on its maiden voyage from Southampton to New York (Wade, 2012). Of the two thousand two hundred and twenty-nine passengers estimated to be aboard, only approximately seven hundred survived. The substantial proportion of victims was primarily the result of the small number of lifeboats available (Dickinson & Vladimir, 1997). The disaster echoed around the world. Lawmakers and ship builders were now obliged to develop more stringent standards of maritime safety to protect against ever again suffering such a devastating loss of life (Gaouette, 2010).

Following the Titanic disaster, an International Convention for the Safety of Life at Sea (SOLAS) was adopted (International Maritime Organization [IMO], 2020). The underlying intent was to ensure the regulation of every aspect of life on board that could pose a danger to human life. In June 1960, the fourth SOLAS convention expanded this to maintaining the highest possible standards with respect to all equipment, operations and construction (Roach & Smith, 2012). The IMO also reached the conclusion that all rules were required to evolve in step with the technological developments of the nautical world (IMO, 2020). However, as the speed of technological innovation increased, formal agreement of rules was replaced by tacit agreement. This markedly improved the speed with which publication and enforcement could be understood (Roach & Smith, 2012). As a result of this innovation, even today reference is made to the SOLAS 74 convention, albeit modified and updated many times over (IMO, 2020).

In addition to the technological evolution of maritime transport, there has been a similar expansion in the sheer number of seafaring vehicles (Eliopouloua et al., 2016). Equasis (2019) reported that the number of vessels worldwide increases yearly, with larger ships being built for cargo and passenger transport (see Figure 1).

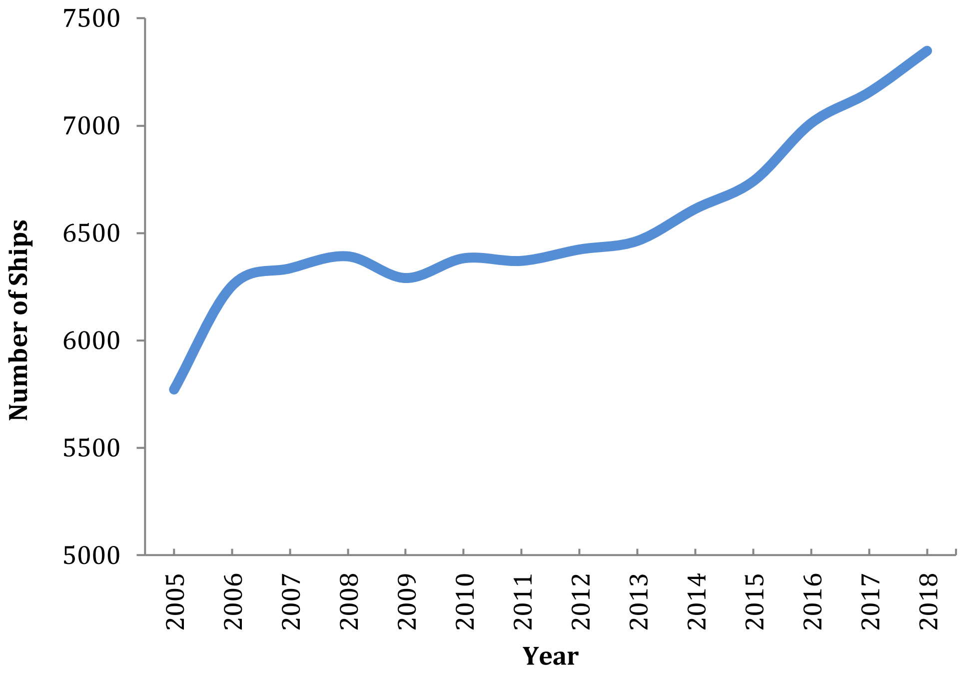
Figure 1. The World Fleet (not including fishing vessels) 2010 – 2018



Note: Data Source: Equasis (2019)

When including fishing vessels, IHS Markit reported an estimate of 118,525 ships operating within the world fleet (IHS Maritime & Trade, World Fleet Statistics 2019). Of particular interest to the present study, Equasis (2019) also reported a similar, steady increase in the number of passenger ships, with approximately a thirty percent increase noted in the world fleet over the past decade and a half (see Figure 2).

Figure 2. Ships in the World Fleet 2005 – 2018

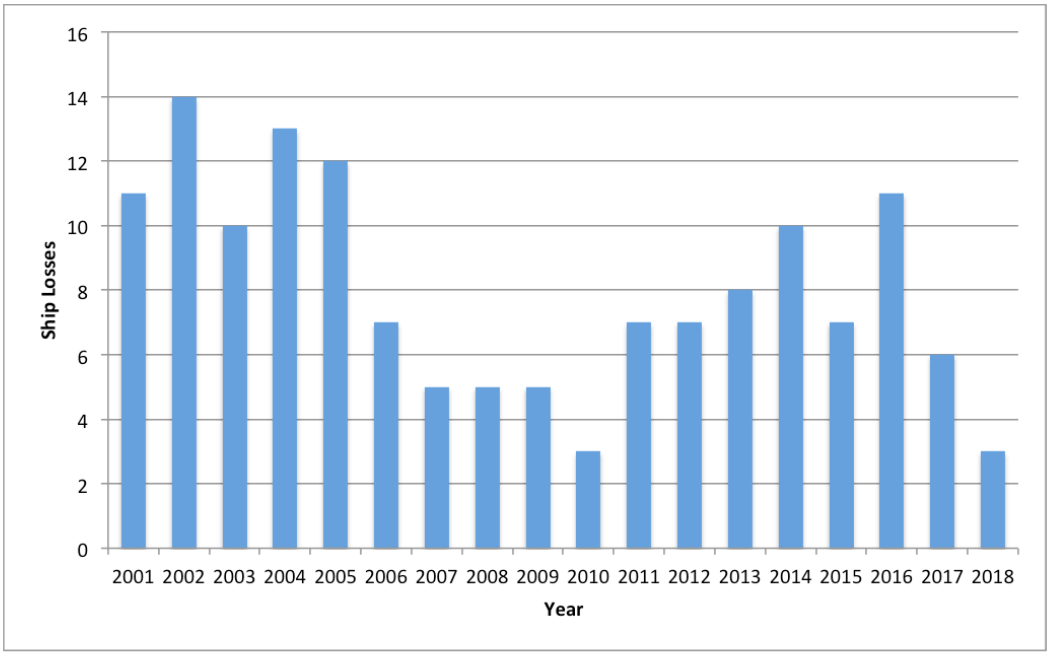


Note: Data Source: Equasis (2019)

Despite maritime regulations, shipping accidents are still common. The European Maritime Safety Agency (EMSA, 2020) reported 23,073 ship casualties and incidents in the period from 2011 to 2018. Second only to cargo ships, passenger ships were the vessels with most casualties, accounting for 23.7% (EMSA, 2019). The number of vessels involved in incidents has decreased in 2019.

However, the number of passenger vessels involved in casualties has remained stable (EMSA, 2020). According to data published by Allianz Global Corporate & Specialty SE, an estimated 144 passenger vessels were lost between 2001 and 2018 (see Figure 3).

Figure 3. Passenger Ship Losses between 2001 and 2018



Note: Data Source: Allianz Global Corporate & Specialty Safety and Shipping Review (2013, 2018).

In 2018, there were 832 reported passenger ship incidents, with 331 people on board being injured and four fatalities (EMSA, 2019). Of these, 47% were groundings and collisions. Following an analysis of the events, human action was found to have been the main contributing factor to more than half of the accidents (59.4%), followed by system or equipment failure (29%). The elements within the human action category that were found to contribute the most were: inadequate working methods in personnel and manning, planning and coordination within crew management and social environment safety awareness. In the time between 2012 and 2018, the number of fatalities on passenger vessels has seen a general decrease, with 60.4% of the victims represented by passengers (EMSA, 2019). Despite the average decrease in number of fatalities on passenger vessels, passenger safety and emergency training remain of the utmost importance (Vanem & Skjong, 2006; Wang et al., 2020).

The present-day cruise line industry regularly uses ships many times the size of the Titanic (Brown, 2016). The number of passengers they now hold has similarly increased. To optimise evacuation processes and protocols requires understanding of human behaviour in potentially life-threatening situations. Behaviour of an individual may be affected by traits, which they may possess, or systems within which they may function (Wang, 2020). In a maritime disaster, this behaviour may be further impacted by interactions with potentially thousands of other individuals. It has been suggested that evacuation occurs as a group and that an individual's movement is thus guided by group movement (Santos & Aguirre, 2004). Yet, the individual remains a sentient agent in the emergence of such groups. Once a valid behavioural model is constructed, it then becomes necessary to understand the best way to promote the most effective decision-making (Newell et al., 2007). This may then be incorporated into computational models to create a combined model of efficient evacuation. Ultimately, this may be used to ensure the highest standards of care and to avoid potentially devastating loss of life in disaster scenarios.

1.2 Thesis Scope

Research on international maritime disasters and human behaviour during evacuations is scarce (Casareale et al., 2017; Vanem & Skjong, 2006; Wang et al., 2020). Due to this scarcity, it is necessary to draw comparisons with other types of disaster evacuation in order to understand potential influences and possible optimizations (Canter & Finiti, 2015). The majority of studies on evacuation have been conducted with respect to building fires (Canter, 1980; Casareale et al., 2017; Galea et al., 2011; Gershon et al., 2012; Wang et al., 2020). This research has been fundamental for the creation of computational models of evacuee behaviour (Wijermansa et al., 2013). These models are effective for calculating rates and flows of movements for numerous agents with predetermined characteristics. They provide averages with error terms concerning the overall speed of crowds in terms of metres per second or floors per minute. Certain models have been shown to accurately simulate human fire evacuation behaviour (Joo et al., 2013). However, it has been suggested that they are incapable of incorporating potentially irrational or unexpected exercises of free will (Kuligowski et al., 2017). Similar levels of understanding and modelling are required for the improvement of maritime evacuations.

The aim of an evacuation model is to accurately and comprehensively predict and simulate human behaviour (Santos & Aguirre, 2004). Such a mathematical model needs to be founded upon a comprehensive conceptual model. This conceptual model needs to be built up from well-supported theories in social and behavioural psychology concerning the prediction of how people will act in emergencies (Kuligowski et al., 2017). This is necessary as each disaster scenario will have a unique evolution with qualitatively and quantitatively different choices. To optimise evacuation, it must be understood how to best guide these choices. Additionally, it must be considered how the attributes of an agent may affect any tendencies towards certain behaviours, and how these tendencies might be overridden by interactions with other agents. Human behaviour is highly complex which leads to a tendency for its over-simplification in simulations (Pan et al., 2006).

The aim of the present study is to provide the foundations for the development of a comprehensive model of human behaviour in maritime evacuation scenarios. This thesis describes three interlinked studies intended to crystallise a methodological approach for effective future research in this area. This will build upon findings of a previous study

(Canter & Finiti, 2015), which provided evidence for the existence of a general model of human behaviour in evacuations. Canter and Finiti (2015) found that sequences of acts in both fire and maritime evacuations were broadly similar. Further exploratory analysis of data extracted from the cohort of that study suggested there to be differences in the behaviour of participants when grouped by gender, age, companions and experience. These categories are similar to the extensions proposed in previous research (Fangqin & Aizhu, 2008).

1.3 Research Objectives

The current state of knowledge in the field of human behaviour in maritime evacuations is lacking specificity. Despite several ship evacuation models made available (Galea et al., 2014; Kim et al., 2019), these are largely based on the comparatively vast amount of literature available on building evacuations. However, current maritime evacuation models fail to consider passengers as sentient, psychological agents. These models often demonstrate lack of understanding of the effects that specific ship-related characteristics can have on the behaviour of passengers. The interaction between the passengers and the environment is fundamental in ship evacuation processes. Yet these differ from those in fires in terms of size, numbers and threat. As such, specific maritime research is still under-represented in the current literature and available evacuation models (Nevalainen et al., 2015). Additionally, existing models still have the tendency to divide the evacuation process into phases, mainly starting from the sounding of an alarm. It must be noted that, even before an alarm, there are factors and interactions that can activate passengers and push them to start the evacuation process (May, 2001; Nevalainen et al., 2015). Although it is possible to see advancement in model development, the psychological aspect of the models does not seem to keep pace with the computational aspects (Kuligowski et al., 2017). A possible cause for this is the current psychological methodology's lack of integrable quantitative output.

Current methods, including behavioural sequence analysis and the talk-through method of data collection, require assessment for validity purposes and for possible beneficial refinements (Lawson et al., 2013; Shiwakoti et al., 2020). Similarly, acquiring data that is compatible with modelling procedures requires a redirection of current methods. This is vital, as human behaviour in complex situations may be affected by complex interactions (Frey et al., 2011; Kuligowski, 2011a, 2011b; Mileti & O'Brien, 1992; Savage, 2019; Thompson et al., 2018). These complexities are compounded by variables such as personality types, contexts, and type of event (Galea et al., 2015; Lee et al., 2003). Research on maritime evacuations in general is still limited today, especially from the behavioural point of view (Wang et al., 2020). There is a need for a greater volume of empirical data for investigation. This will allow for an acceleration of research towards the ultimate goal of optimising maritime safety.

1.4 Aims of the Study

Disasters are unpredictable and potentially devastating. It is of utmost importance to prepare for all eventualities to avoid tragic loss of life. However, due to their nature, disasters are difficult to examine from a decision-making perspective (Casareale et al., 2017; Kvamme, 2017; Wang et al., 2020). Consequently, previous research and data are scarce. This is especially true for maritime disasters (Nevalainen et al., 2015). Thus, an overarching aim of this thesis is to describe a path towards being able to redirect and accelerate research concerning maritime evacuations. This is necessary to achieve unity with the modelling progress evident concerning fire evacuations.

The first step towards this aim is taken with the first study described in this thesis. It is a replication of a previous study (Canter & Finiti, 2015) to check the reliability of results obtained through the implementation of Behavioural Sequence Analysis (Canter et al., 1980).

Evidence for reliability of a method is determined through producing similar results upon repetition (Wilson, 2005). Analysis was undertaken on a different sample of the population of survivors of the Costa Concordia. Further analysis was undertaken to examine potential intra-cohort differences. The aim of this was to detect differences in sequences of actions, which could be explained by reference to existing psychological literature.

A second aim of the present study was to examine a method for increasing the volume of data concerning maritime evacuations synthetically. This required the assessment of whether a valid method of creating reliable data for examination is provided by studies involving the imagination of emergency scenarios. To confer validity, evidence must be provided for this proposition. In the second study contained within this thesis, participants were encouraged to imagine themselves in a situation similar to that faced by the passengers of the Costa Concordia. They were interviewed with respect to the decisions and actions they chose. The third study involved a systematic comparison of the data produced imaginatively with the data extracted for the first study from transcripts of the testimony of real-life Costa Concordia passengers. These comparisons were made between each cohort and between different categories of individual in each cohort.

It is predicted that analysis will produce empirical data on human behaviour, showing results between real-life data and lab setting data to be similar. However, it is predicted that, as the level of scrutiny increases, more contradictions and inconsistencies will become apparent. Dependent on the precise nature of any inconsistencies found, a novel methodology for the investigation of emergency scenarios will be proposed. This will involve expanding investigation from acts resultant of decision-making to the quantifiable calculations involved in such decisions. This will further allow for a quantifiable comparison between natural decisions and optimal efficiency. Additionally, data produced will be more compatible with modelling requirements. This methodology will be low-cost and adaptable to providing high quality evidence for the best way to provide authoritative instruction.

1.5 Novel Contributions

One of the novel contributions to knowledge this research has presented is the replication of a previous study (Canter & Finiti, 2015). The present study collected accounts from a different sample of the population of survivors of the Costa Concordia maritime disaster. The method involved Behavioural Sequence Analysis consisting of the creation of a generalised taxonomy of acts. These showed a significant correlation with the acts reported in the previous study. To the researcher's knowledge this is the first study to use sequence analysis, which has replicated results from two different samples of a population of a single real-life disaster. This study therefore confers reliability and validity on the behavioural sequence analysis method.

A further contribution to existing research is a unique comparison of the talk-through method's imagined accounts versus real-life accounts. The lack of such comparison had been specifically identified in Lawson et al. (2013) when proposing this new methodology. The present study therefore exists as a potential source of validity for the talk-through approach. Despite other forms of validation (Lawson, 2011; Lawson et al., 2009a, 2009b, 2013) providing encouraging results, it can only be considered ecologically valid if the data produced sufficiently mirrors that produced in real-life scenarios. The present study provides declining evidence of validity with greater depth of analysis.

Finally, and possibly most importantly, a new methodology for behavioural sequence analysis was proposed. The talk-through method holds potential future value as a manner for producing accurately imagined accounts of real-life events. However, it requires further refinement and validation. Similarly, behavioural sequence analysis needs reorienting towards answering the psychological questions it sets out to investigate. There is also redirection required in the data created for psychological results to be compatible with computational modelling. Consequently, a new method for the creation and collection of data is proposed which obviates the limitations of the current methodology.

Chapter Two: Literature Review

The importance of research into human behaviour in emergency scenarios is reflected in the constancy with which it has been subject to study over the past sixty years. There is arguably nothing in psychology more important than understanding and implementing methods to prevent loss of life. To optimize emergency procedures, prevention strategies and evacuation plans it is necessary to understand the behaviour of humans as autonomous, sentient agents (Galea et al., 2011; Kuligowski et al., 2017). As actions and intentions become better understood, predictions based upon psychological theory and research become more accurate in the real world. As predictions improve, so do the outcomes of disastrous events. The first, critical step towards avoiding devastating loss of life is to advance understanding of human behaviour in emergency situations.

Early research identified a point of fundamental importance to the potential modelling of human behaviour. Actions in emergencies do not seem to be driven purely by panic and irrationality (Drury, 2006). Instead, it was noted that actions and reactions in emergencies are not unsystematic and disorganized (Canter et al., 1980, 1990; Quarantelli, 1960). This recognition has been further validated in more recent literature (Casareale et al., 2017; Drury & Cocking, 2007; Wang et al., 2020). However, there are many possible interactions, which result in issues with the disentanglement of actions and intentions. The autonomous, sentient agent becomes a systemic part of its rapidly changing environment. Various interrelating internal factors intrinsic to behaviour in emergency scenarios are duly informed and perhaps interrupted by the specific situation. Such issues result in difficulties in understanding and predicting such reactions. The type, condition and evolving nature of disasters, all multiplied by the human factors and characteristics of those involved, creates immense possible variability in human behaviour (Fritz & Marks, 1954; Mu et al., 2013; Wang et al., 2020).

The disaster of the Costa Concordia shipwreck necessitated thorough analysis from different points of view. There were technological and procedural questions to be asked concerning naval engineering, mechanical safety and emergency systems. There were also answers required with respect to mass evacuation processes and the psychology of human reactions in emergencies (Kvamme, 2017). The incident itself falls into the category of "man-made disaster". It is considered to be a catastrophe fatally precipitated or determined by human factors (De Vita et al., 2014). The word ‘disaster’ assumes different meanings among the different disciplines required to study the events that determine such a dramatic experience. As a symbolic representation, it has been suggested that the word ‘disaster’ possesses the typical characteristics of a "sponge word" (Quarantelli, 1978; 1985). This phrase implies that initially, as a word, it is very absorbing and thoroughly describes the complexity of the reality of a disaster. However, when you try to squeeze it to conceptualize it in general terms, its meaning returns very little. This inherent ambiguity means that in different scientific approaches, the definitions of the term disaster are dictated in general by the magnitude of the event and by the discipline that studies it (De Vita et al., 2014). However, across disciplines, there are certain commonalities. One common element in any theoretical approach is that the disaster occurs at a well-defined and easily identifiable moment (Al-Madhari & Keller, 1997; Lindell, 2013; United Nations Office for Disaster Risk Reduction, 2009). It is also commonly accepted that when observing a disaster in terms of its impact on the community involved, its effect is considered broad enough to cause the upheaval of the community’s social life through serious disruption to its functioning (Quarantelli & Wenger, 1985).

In addition to requiring a clear definition of the word ‘disaster’, it is also necessary for the study of human behaviour in emergencies to evaluate the different phases of a disaster. To do this, it is necessary to recognise and to isolate critical moments to try to understand when and how they impact upon people and affect any interactions. One such proposal is that the main phases of a disaster are prediction/prevention, alarm, impact, relief and recovery (Pepe, 1996). The alarm and impact phases are of particular interest to this research. The alarm phase consists of the period in which it is possible to gather elements that allow for the prediction of an imminent catastrophe or an incident of dramatic significance. It often coincides with, or precedes by a few minutes, the impact phase. In the case of the Costa Concordia, this phase consisted of the moment the ship began to heel, the initiation of evacuation procedures and requests for assistance (Alexander, 2012). During these phases, human behaviour is driven by complex variables. These include heightened emotions, which play an important role in the individual and crowd dynamics that develop (Day et al., 2013). There were over four thousand individuals, both passengers and crew, on board the Costa Concordia at the time of the incident. This is approximately double the number involved in the Titanic disaster. That there were comparatively few fatalities may be due to improvements in maritime safety (Schröder-Hinrichs et al., 2012). However, as stated, the severity and environment are critical factors in the definition of disaster. The fact that criminal proceedings were brought against the captain and several members of the crew would imply negligence and wrongdoing (ANSA, 2014). Yet, despite all differences, this qualifies as a man-made disaster and requires investigation both at an individual level and at a crowd level. Such investigation is the first step towards the optimisation of maritime safety (De Vita et al., 2014).

2.1 Emergency and Trauma

With the evolution of globalisation and mass transportation, emergency situations involving vessels, such as aboard ships and planes, are becoming less rare. Due to the immense number of people, vessels and routes in constant use in the modern era, awareness of incidents has become commonplace with respect to the daily lives of individuals (Rautela, 2006). However, such incidents can have a devastating impact on those involved. They may constitute a real trauma, even when not experienced directly. Transport disasters are traumatic events, which, unlike other stressful life events, are characterized by a collective nature. Entire communities may be involved, with damage to individuals and family groups, as well as disrupting the overall functioning of a human group as a whole (Frailing & Harper, 2017).

De Vita et al. (2014) explain how the Costa Concordia shipwreck had a traumatic impact on the collective. It generated individual and collective responses at both practical and emotional levels. Passengers and crew members constituted a small community, a human group that shared the same destiny. The accident location, in this case the Giglio Island, suffered disastrous losses. The ship's capsizing inflicted environmental and economic damage on the island. It also impacted the lives of the islanders. On the night of the shipwreck, most of the inhabitants took charge and helped the survivors, offering warm clothes, blankets, and places to stay. The whole island experienced emotional shock. Similarly, passengers on large cruise ships are dependent on crewmembers. Emotional dynamics of trust and security were established, yet these dynamics disintegrated. In the study of the Costa Concordia shipwreck, it is therefore crucial to conduct an analysis of emergency and trauma response considering actions, reactions and interactions at both an individual level and a collective leve**l (**De Vita et al., 2014)**.**

With respect to a traumatic event, it would seem to be the event itself that is traumatic. However, from a systemic point of view it is equally true that it is the reaction to the event which leads the event to be considered traumatic. The American Psychiatric Association's (2013) *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (5^{th} ed.; DSM-5;) defines a traumatic event to be "any event (or events) that may cause or threaten death, serious injury, or sexual violence to an individual, a close family member, or a close friend." (p.830) However, experience and clinical literature highlight how individual differences in interpretation, explanation and attribution of meaning to events reflect in differences in the perception of said events. That which is traumatic for one individual may not be for another (Robinson & Larson, 2010). It is well documented that not all persons exposed to a traumatic event develop post-traumatic stress disorder (Blake et al., 1990). It is therefore not a consequence of the event alone, but rather that it is due to the role of individual genetic, psychophysiological and personal history differences (Brewin et al., 2019). These individual differences play a role in determining collective interaction dynamics, which in turn affect both the individual and collective definition and sense-making of the situation (Norris, 1992). Thus, it is important to consider how people attribute meaning to events. Furthermore, the understanding of differences in attributions within emergent groups within a large-scale evacuation will affect individual behaviour. As stated, the over-simplification of human behaviour is a potential limitation of models (Pan et al., 2006).

2.2 Theoretical Perspectives of the Attribution Process

The conscious perception of emotions is one of the main characteristics that distinguish human beings from animals. While animals experience emotions in a more instinctive way, humans have developed neuronal circuits that allow them to recognize emotions consciously. However, according to LeDoux (1998) we do not always manage to have full perceptual control of our emotions, as is the case with fear. "From the point of view of survival, it is better to respond to potentially dangerous events as if they were in fact the real thing than to fail to respond" (LeDoux, 1998; p.368). Joseph LeDoux discovered the amygdala to have a fundamental role as the brain alarm system. It is capable of alerting the rational part of the brain in the prefrontal lobe to deal with an emergency within a fraction of a second. Emotional processes do not require a verification of the truthfulness of a stimulus. Instead, they emerge from unconscious cognitive processes. LeDoux (1998) describes this process with a simple example: If, while walking in the woods, we step on something that makes a crackling sound, it could be a dry twig or a snake. We do not have to evaluate in detail whether what we see is a snake or not. We don't need to think of snakes as reptiles or that snakeskin is often used to make shoes and handbags. All these details are irrelevant and even harmful for an effective, quick and potentially life-saving reaction. The brain must only be able to identify and store elementary cues. Subsequently, the coordination of the fundamental information with the cortex allows for the verification of the stimulus, whether it is in fact a snake, or interrupts the response with hyperventilation, screaming, or flight. The processes of perception and reaction are therefore attributed to unconscious cognitive processes (LeDoux, 1998, 2012; Phelps et al., 2004**).**

Memory accompanies us continually, more or less consciously, linking past experiences to the present (Squire, 2004). Its function is not limited to the processing and encoding of past ideas, feelings and emotions; to even be aware of oneself is a mnemonic act (De Vita, 2011). Any new information, or the combination of a set of cues, necessarily implies a memory function that allows the integration of the experience in the present (Squire & Dede, 2015). The interpretation of external stimuli is only possible based on personal reference schemes. These are constructed through constant experiential learning (Illeris, 2007). Erickson (1984) emphasized that all individuals experience various learning processes that affect the overall functionality of a person. These processes may also affect physiology via blood circulation, muscle behaviour and all the various organ systems.

Whenever an individual is activated by a particular stimulus, experientially learned behaviours arise. This type of memory is defined as "implicit" or unconscious. It is information that does not require remembering (Schacter, 1987). Implicit memory influences the individual without conscious awareness and can be categorised as procedural, associative and non-associative **(**Critchley et al., 2000; Schacter, 1987). Procedural memory is created through procedural learning. It uses learned scripts and allows individuals to perform tasks automatically or semi-automatically, for example riding a bicycle, writing, or typing. Through associative learning we understand that a stimulus is associated to another stimulus, or a particular response, even without a conscious memory promoting the association **(**Ochsner & Gross, 2005)**.** Non-associative learning involves two common categories: habituation and sensitization (Kuligowski, 2011a). These consist of the increased or decreased association of a response to a stimulus by the repetition of the single stimulus (Sato, 2017).

Faced with a danger, the limbic system of the brain is immediately activated. The function it fulfils is to prepare the cortex to face the danger in a more evolved way. The emergency situation will be treated not only by the activation of the fight or flight system, but also through an evaluation of the stimulus and the possible strategies for appropriate reaction (Sokolowski & Corbin, 2012; Taylor, 2005). Here we enter the theoretical area of the attribution process, that is, the process of integrating all the emotional, cognitive and motivational information that allow for the perception of the events that happen and the causes that determine them (Ross, 1977). Humans tend to prefer environments where events are predictable and controllable, thus victims of a disaster are highly motivated to understand why these events occurred (Yule, 2000). Attributions are the interpretations of the events that happened in terms of success and failure, depending on the outcome and in relation to a particular context or task (Weiner, 1972a). The intrinsic value of the attribution process is the maintenance of a capable sense of self and the preservation of a good level of self-esteem. A favourable concept of self provides the resources to face and overcome difficulties, mitigating the feeling of unpredictability and uncontrollability of the future while orientating it to success (Krishna, 2006; Weiner, 1972b). Causal attribution is a cognitive process through which the victim of a traumatic experience gives it meaning in an attempt to explain how it could have happened. It serves to maintain self-esteem and confirm the idea of one's own world as predictable and controllable (Yule, 2000).

This first phase of an emergency response sees the participant of the disaster assess all the implications of the current event (De Vita et al., 2014). These include the attribution of causality, the assessment of the probability of survival, the assessment of the possible consequences, the discrepancies of expectation and the urgency to act. Only once this phase is complete does the possibility of controlling the event, the possible modes of control and the eventual regulation of the event arise. These processes are referred to as coping strategies (Scherer, 2001). However, with regard to the present thesis, it is apparent that the acts a person may recount having committed during a real-life event may not mirror their actual behaviour (Wood, 1980).

2.2.1 Coping

Coping mechanisms are utilised during interactions that challenge or overcome the resources of a subject. Such mechanisms include multiple components, such as the cognitive assessment of events, reactions of discomfort and personal and social resources (Skinner & Edge, 1998). The study of coping mechanisms in emergency situations allows for the identification of fundamental components of the psychological process activated by individuals struggling with stressful events (Folkman, 1992; Folkman & Lazarus, 1985; Holahan et al., 1996 Lazarus, 1991, 1993, 1993b; Moos & Schaefer, 1993). Psychological literature highlights two relevant coping research approaches: interindividual and intraindividual. The former approach focuses on individual factors, personal lifestyle, habitual strategies, and personality. The latter approach focuses on strategies related to the situation or specific event, which determines a series of response options from which an individual can choose the best solution to face the struggle. Hence, intraindividual measures are situation-specific (Parker & Wood, 2008).

Folkman and Lazarus (1985) report that the two main processes, which determine the impact of stressful events in a given situation, are cognitive evaluation and choice of coping strategy. The cognitive evaluation, or appraisal phase, is the evaluative process that determines why and to what extent an individual perceives a specific situation as stressful. Such evaluation develops through different stages (Strobe & Strobe, 1996). Primary appraisal acknowledges the quality of the situation to be positive, negative or neutral. Following this, an individual goes through secondary appraisal, or coping, which involves the evaluation of possible strategies and their effectiveness. Coping mechanisms are active conscious processes, whilst primary appraisal is an unconscious and cognitive process. It is, however, important to note that emotional and cognitive experiences are dynamic, interactive, continuous cycles linked to the environment (Lazarus, 1984). The emotional encounter between the subject and the event involves the contribution of values, beliefs, goals, personal experiences of the individual, the setting and the community that in fact constrain and define the situational scenario (Folkman et al., 1986). In terms of a disastrous event, like a maritime emergency, the ship exists as a co-constructed context in which all passengers and crewmembers play a role of reciprocity and interaction.

Given that, at the primary appraisal stage, the victim immediately recognizes the quality of threat, challenge and potential damage, at the time of coping the victim directs attention towards every possible resource (De Vita, 2011). Analysis is conducted with respect to the available options aimed at reducing, controlling and tolerating external and internal requests, including the possible conflicts between the two. Coping strategies that originate from the interactions between individuals and context can be classified in two categories: problem-focused and emotion-focused (Cohen & Lazarus, 1973; Pearlin &

Schooler, 1978). Problem-focused strategies aim at preventing or changing the source of the stress. These strategies are activated to regulate the negative feelings resulting from the event by minimising the potential impact of the event. Emotion-focused strategies aim at minimizing negative emotions caused by the stressful event at each stage as it develops. An example of problem-focused coping can be presented as: *I have to get off this ship immediately, I have to get to the lifeboats, but I am in the cabin and there is no lighting in the whole ship… I could try to use my phone to illuminate the path.* In this case the coping strategy has a problem-focused function, aiming at reducing the negative impact of the likely event by looking for a solution in the environment. An emotion focused coping mechanism can be portrayed as: *I'm afraid of drowning, I don't want to die, I have to follow crewmembers' instructions for a safe evacuation and save myself.* This emotional coping mechanism is oriented towards the regulation of emotions through self-assurance. These occur to avoid psychological paralysis during the potentially emotionally unsustainable experience of possibly facing death and not being able to do anything to avoid it.

Coping responses prove to be valuable for a successful adaptive outcome of the human-environment relationship (Skinner & Edge, 1998). They contribute to the construction of the stressful event within the meaning of the interpretation of stress. In experiencing a potentially hazardous situation, individuals perceive the possible threat, challenge or damage. This is then analysed in parallel. Internal factors, such as values, beliefs and goals, are combined with assessment of the situation itself in terms of controllability, danger and potential duration. These are then channelled into an evaluation of their own idea of their own ability to respond – their coping behaviour (Folkman et al., 1986; Kinateder et al., 2015; Kinsey et al., 2019). If the potential victim of a cruise ship accident believes the situation can be controlled, and that there is no risk, then there is no stress. Whether this self-assessment of the ability to manage the interaction is true is irrelevant. There may well be a moment of realisation at a later point, but for the present purposes, the coping strategy has been effective.

Following these initial stages of primary appraisal and coping, there exists a reappraisal stage. This stage consists of the reconsideration and re-evaluation of the outcome of the implemented coping strategies, on both internal and external conditions, in order to determine subsequent actions (Ochsner & Gross, 2005). Reappraisal affects the meaning individuals give to experiences. If the reappraisal mechanism is positive, that is the coping proved to be effective, it will increase one's self-esteem and estimation of self-competence and will therefore probably be reapplied (Brande, 1994; John & Gross, 2004). Coping is a circular process where, each time a stressful event arises, the actions, strategies and resources that the individual has experienced as functional to their well-being will be implemented (Stephenson et al., 2016). The failure of coping strategies generally produces imbalance in the individual and is not predictive of high self-esteem and positive perception of the outside world (Yalçınkaya-Alkar, 2020). Personal coping styles evolve as a result of various interacting factors. These may vary due to personality characteristics, contingent transitory states, or the amount of positive or negative feedback received (Stephenson et al., 2016). There are also further psychological fundamentals, such as an individual's locus of control, which may impact upon the variability of coping styles (Scott et al., 2010).

There are no right or wrong coping strategies, only strategies or reactions that an individual deems to be effective in facing a situation. The chosen strategy is the one an individual believes to be the best within a specific stressful situation (Stephenson et al., 2016). Its effectiveness may generally only be evaluated in hindsight. However, even with the benefit of hindsight, it is very difficult to state with absolute certainty a correct way to react in a potential situation. For example, imagining how we would act and react during a maritime disaster involving a cruise ship with more than 4,000 people could result in a multitude of potential actions. However, when facing the actual event there may well be actions and reactions previously not considered. This may be due to the individual differences previously stated, and the individual intensity of our emotional reaction and the consequential effectiveness of emotion-focused coping strategies (Folkman et al., 1986). For example, fear could lead to paralysis instead of leading towards lifeboats. Rage could be effective in demanding lifeboats to be lowered but could eventually prove ineffective if uncontrolled. An emotionally charged interaction, resulting in aggressive reactions with personnel in charge of the evacuation, may prove unbeneficial. The effectiveness issue of coping has also been studied in terms of resilience. Here, resilience is defined by the ability to resist intensely stressful events in order to achieve positive outcomes (Luthar et al., 2000). Resilience is an intrinsic quality of the individual associated with effective coping. Thus, while the same event can be experienced in terms of threat or challenge, depending on the reaction and interpretation of the individual, it is important to investigate which risk factors or protective factors intervene in the attribution and evaluation process (Rutter et al., 1970).

Every situation as critical as a disaster is unique. Those involved are unique in their individuality and in their collectivism. Similarly, the exact circumstances are unique. Within these unique factors it is, however, possible to question and investigate, from a psychological point of view, the variables affecting the genesis and dynamics of response processes to the critical emergency of a disaster (De Vita et al., 2014). Coping models relying on Lazarus and Folkman’s (1984) approach have been criticised for their individualist approach (Berg et al., 1998). The criticism emphasizes the idea that the individuals experiencing stressors are part of a social context and therefore react to stress in collaboration with other individuals involved. This is particularly applicable, and requires careful consideration, in the analysis of disastrous events involving entire communities. It must be evaluated how exactly context and the presence of other people involved in a disaster affect coping processes. Berg et al. (1998)

proposed a social contextual model of coping aimed at describing the process by which individuals, relating to others involved, anticipate and confront problems. They noted that often, while it is recognised that individuals involve others in their problem-solving processes, such involvements take the generic form of social support. Others may be involved in coping mechanisms as a source of information, advice and support, as points of reference, or as mutual and compensating collaborators within coping efforts. It has previously been noted that clear direction from a person with perceived social influence improves evacuation (Gershon et al., 2007).

Faced with danger, people generally try to manage the situation by attempting to understand and identify what the actual danger is. This is done through basic problem solving through the operation of evaluating the available resources and the subsequent behavioural decision making based on these evaluations (Bransford & Stein, 1993). The operation can be further understood through risk management. This may be viewed as an evaluation undertaken in three precise moments that occur in rapid succession: identification of risk, risk evaluation and risk reduction. The perception and identification of risk is a crucial moment in the pre-evacuation phase of an emergency scenario. It is the perception of risk itself that initiates the human factors affecting the decision to evacuate (Kuligowski et al., 2010). In the first phase of a mass emergency, that of the recognition of a real danger, the two primary factors for evaluation are information coming from authority figures and environmental cues such as smoke, water or explosions (Gershon et al., 2007). Furthermore, another fundamental factor upon which primary evaluations may be made is information that can be derived from other people's behaviour. This will involve the attribution of meaning to the behaviours of others, for example deducing that if others stop and wait, there probably is no real danger (Proulx, 1994). In the risk assessment phase, on the other hand, the contents of warnings, alarm messages and the credibility in terms of authoritativeness of the source of the alarm are very important (Lamb et al., 2012). Finally, in determining which actions or behaviours can be useful for reducing risks, people tend to use schemes learned in previous experiences, follow what others do and using common sense according to their own cultural references (Proulx & Sime, 1991).

Coping resources, which we also find in the specific literature of mass emergencies as a response to the stress of danger and emergency, refer to two processes of thought: problem-solving and decision-making. Problem-solving involves the continuous and constant analysis of a critical situation, promoting and evaluating possible solutions (Perry, 1979). Decision-making, which is the mechanism that goes hand-in-hand with each phase of problem-solving, provides useful actions and behaviours for mitigating the critical situation. Decision-making may be considered to be a part of problem-solving. It is the result occurring at each successive level of the solution of the problem and impacts upon further problem solving to be undertaken. From a cognitive point of view, the problem-solving process involves a variety of mechanisms concerning different types of memory. This will include operational memory, short-term and long-term memory, and procedures for planning mental operations and for representing information. It is a cyclical process consisting of seven different phases identified by Pretz, Naples, and Sternberg (2003; pp. 3-4):

1. Recognize or identify the problem.
2. Define and represent the problem mentally.
3. Develop a solution strategy.
4. Organize his or her knowledge about the problem.
5. Allocate mental and physical resources for solving the problem.
6. Monitor his or her progress toward the goal.
7. Evaluate the solution for accuracy.

These various phases do not necessarily imply a set, sequential order. Instead, they are part of a cycle which, when completed, begins again with the emergence of a subsequent critical event to be faced (Pretz et al., 2003). They inform a decision to be made for the behaviour to adopt in order to avoid danger, aimed at salvation and survival. Effectively, decision-making is an intricate process, involving various cognitive representations. These cognitive representations are the context in which the individual assesses and interprets events to differentiate and choose between possible courses of action (Von Winterfeld & Edwards, 1986). However, during a disastrous event in which survival is threatened, these representations may be interrupted (Kerstholt, 1994). Emotional conditions, such as anxiety, fear and terror, will have an effect on cognitive processes. Similarly, time limits on the evaluation of possible decisions may exacerbate these effects to interfere with decision-making and thus the overall problem-solving process. These factors influence the process both in terms of the representation and assessment of the event, and the evaluation of viable strategies and actions to be implemented (Bless & Schwarz, 1999; Hesse et al., 1997).

2.2.2 Emotions and Stress

Involvement in a disaster is generally perceived to be a traumatic event. The potential physical trauma is accompanied by strong emotional stress, fear, anxiety, and terror. A threat is identified, real or perceived, which is evaluated to have the potential to exceed the individual’s endurance capacity. Thus, the perception of danger is subjective as individuals have their own self-quantified threshold of adaptation to danger (Schwarz, 2000). Facing a threat can lead to the loss of perception of personal competence. This may result in the inability to construct action schemes, both mentally and concretely, and may involve the experience of all the physiological correlates typical of fear. Fear is a complex emotional system that allows individuals to relate to the environment. It is an adaptive emotion, which encourages safe exploration by recognising and limiting the risks to minimise potential damage. It is a system that follows a temporal and hierarchically organized succession line. This extends from the perception of danger to the awareness of the emotional reaction to the implementation of the cognitive and behavioural reactions. Emotions fulfil the function of filtering and categorising remembered events as well as drawing similarities to current and future expeditions. They are necessary to react to the environment in order to prepare reactions and to organise and regulate actions. Emotions guide our behaviours and motivate them.

The prevailing emotion during disastrous events is fear. It is the awareness of fear, whether physically or psychologically, which triggers primary and social motivational systems of safety, survival, defence or attack. Fear is a basic emotion through which an organism attributes a hierarchical importance to considerations linked to safety and survival (Ekman & Davidson, 1994). Being involved in a disaster does not generally fall under everyday experiences. Disastrous situations are considered possible, but only as abstract concepts. From an experiential perspective, it is an unknown emotional experience, strongly linked to the individual physiological narratives of fear in terms of physical, motor and cognitive perceptions (Goleman, 2006).

Fear is often not experienced alone. From a systemic procedural perspective, it is important to consider the environment in which an emotion evolves. Furthermore, to understand and evaluate the behaviour of others in the system, there must be a construction of the emotional reality of that crowd (Neville et al., 2020). To explain and organise the experience, we must consider the individual and collective interactions in combination with the perception of the environment. None of these elements should be considered in isolation. The behaviour of one may be predicated on the basis of that of the other, yet not necessarily in strict causal terms. Rather, from a communicational point of view, words and actions of a person may influence the other (Aguirre et al., 2011; Aguirre et al., 1998). This influence may evolve into emotional contagion where each in turn will influence each other, with a reciprocal rhythm and verbal and non-verbal communicative behaviours. They are simultaneous processes within the group situation. Self-regulation and interactive regulation are simultaneous and reciprocal processes. They are produced by influencing each other simultaneously, in a dynamic and flexible equilibrium (Aron, 1996). Each element influences the other and is in turn influenced (Lee et al., 2008) but neither symmetrically nor following a causal model. Each element of the crowd will act in different ways and with different intensity, yet bi-directionally (Ekman, 1984; Ekman & Davidson, 1994). Each element in turn adjusts itself, in an individual process of controlling the level of activation, while maintaining a state of alertness and the inhibition of behavioural expression. Self-regulation and interactive regulation must be considered with equal attention: behaviour is self-regulating and communicative at the same time (Goleman, 2001).

Emotions also have a social and relational dimension precisely because they regulate interpersonal exchanges and predispose behaviours of subjective interaction. There would be no emotional experience without evaluation of the events and without attributing meaning to them in relation to desires, needs, interests and individual expectations. From a psychological-emotional point of view, the participant of a mass emergency experiences the rupture of any pattern previously learned (Frey et al., 2010, 2011). They become overwhelmed by the intensity of fear and the survival instinct therefore aims for escape. To choose escape routes and actions to implement, the participant will be required to change their internal state both through self-regulation and by regulating others. These others may indeed be interpreted to be a further threat to the participant's safety. In this case, escape behaviour may need to emotionally draw on the aggressiveness of fight behaviour. Essentially, behaviour when escaping from a fire or a shipwreck can be equated to that of fighting for survival (Leritz, 1987). Aggressive behaviours are emotionally characterized by anger, an emotion that shares similar roots with fear in neurophysiological terms. Fear is decisive for the fight or flight decision-making moment, while anger supports the fight and facilitates attack and defensive behaviour.

Emotions and stress are subjective experiences. An event deemed stressful by one person may be of no concern to another. The response to an event is regulated by an underlying self-assessment of competence. This self-assessment is based upon memories of previous experience. However, emergency scenarios are extreme situations which are unlikely to have been previously experienced. Once this sense of competence is breached, it then becomes the responsibility of further subjective coping mechanisms to regulate the rationality and effectiveness of behavioural decision-making. However, these reactions do not occur in a vacuum. The environment is crucial to behaviour. One essential resource, which serves to ameliorate any self-assessed lack of competence, is information gathering. Through acquiring and responding to authoritative instructions in a timely manner, a participant is able to suppress notions of lack of self-competence (Lamb et al., 2012; Xia & Gonzales, 2021). The emotions become controlled, and rationality ceases to be interrupted. The remaining issue is the maximisation of this effect throughout all participants.

2.3 The Dynamics of Crowd Emergencies

In terms of disasters, and the emotional and behavioural reactions of those involved, the starting point is crucial to the way in which all subsequent actions develop. Therefore, research must focus on the first human reactions, which occur at the beginning of, or immediately before, the critical event: the evacuation phase. Evacuations are generally group processes (Drabek & Stephenson, 1971). For example, families tend to reunite and colleagues in offices tend to escape together (Aguirre et al., 1998). A first reference model describes different types of evacuation (Drabek & Stephenson, 1971). Firstly, there is evacuation by invitation. This is when individuals are invited to leave the area, and then choose to do so following an evaluation of the situation. Secondly, there is evacuation by default, which occurs when it is impossible to return to a compromised area. Thirdly, there is evacuation by compromise, which describes when crowds follow evacuation instructions even if they don't deem it necessary. Subsequently, Perry et al. (1981) proposed a model in which evacuations are conceptualised through time and duration. This model consists of four categories: preventive, protective, recovery and reconstructive. A preventative evacuation occurs pre-impact and is of short duration. A protective evacuation is similarly pre-impact, but of long duration. A recovery evacuation takes place post-impact and is of short duration while a reconstructive evacuation is similarly post-impact but is more long term.

Evacuation generally involves a group attempting, collectively, to leave a situation due to risk to safety (Day et al., 2013). This is independent from the theoretical perspective through which the event is framed and the environment in which it evolves. Mass evacuations have been studied within different disaster scenarios and contexts over the years (Templeton et al., 2015). These studies provide interesting points for consideration when examining ship evacuations. One such point is the identification of characteristics particular to the type of crowd that passengers and crewmembers constitute, and their effect on the type of behaviours that emerge during evacuation. A group of people can be defined as a crowd when it consists of a quantifiable number of individuals, in a specific place, in a given time period who share collective objectives and behaviours (Reicher, 1996; Turner, 1982). This has also been termed a 'psychological crowd' (Drury, 2018; Reicher & Drury, 2010). The 3,000 passengers on the Costa Concordia constitute such a crowd. Initially, they were individuals sharing an unfamiliar situation. Yet they came to behave in a coherent manner, respecting a series of rules and tacit values in their behaviour, without them being made explicit or communicated. Passengers on the Costa Concordia can be defined as both a psychological crowd, meaning a group of people sharing a social identity, and as a physical crowd, meaning a group of people sharing the same space maintaining their individual identities and intentions (Reicher, 2001; Reicher & Drury, 2010). Within the disaster, as a shipwreck, the three thousand passengers on the Costa Concordia can also be identified as *a fleeing crowd*. This describes a group of people who share the experience of threat to their lives and the subsequent evacuation from the ship on which they were traveling (Berlonghi, 1995; Cocking & Drury, 2008; Drury & Cocking, 2007).

A community, or crowd, can be observed and constructed through different perspectives. A crowd may be a result of shared movement, generic behaviours, disorder, management and need for control. However, within this research, the focus is on behaviours related to the emergency situation. Literature on mass dynamics in emergency situations notes that the crowd generally does not behave irrationally or antisocially. These are the main two factors often associated with panic behaviour (Cocking & Drury, 2008; Feinberg & Johnson, 2001; Quarantelli, 1960; Schoch - Spana, 2003; Sime, 1995). This relatively recent consensus disconfirms Freud's theories (Freud, 1921) of mass behaviour as abnormal, pathological and instinctive. It also disconfirms Le Bon's concept of the crowd as an entity, which absorbs and revokes individual identity and personal responsibility, promoting uncontrolled, uncivilized and anti-social mass behaviour (Le Bon, 1908; Templeton et al., 2015).

People involved in a disaster seek information. Any behaviour implemented will be based on evaluation of the options derived from the information they obtain (Chernoff & Moses, 1959; Raiffa, 1970). Fundamental to the understanding of crowd evacuation is the access to information and the receiving, perceiving, interpreting and processing of that information (Canter et al., 1990; Cepolina, 2005). However, excess information-seeking may lead to delayed evacuation initiation (Averill et al., 2005). The actual evacuation of crowds requires time to be initiated. This time is needed to perceive and recognise danger and subsequently to concretely activate people towards escape routes (Fahy & Proulx, 2005; Galea et al., 2015; Kuligowski et al., 2017; SFPE, 2019).

For years, security engineers have relied on the simple assumption that when an audible alarm sounds, people start to evacuate immediately. This belief is not necessarily correct (Edelman et al., 1980). It was believed that the speed with which people managed to get out of a building depended mainly on individual physical skills. This was modulated by other factors such as the location of the emergency exit and the development of the event, natural or otherwise, which led to the situation of emergency. However, research has provided evidence for quite a different reality. Following an alarm, individuals tend to employ a significant amount of time in activities not aimed at evacuation. This time has been estimated to be approximately two thirds of the overall evacuation time (Gershon et al., 2012; Kuligowski, 2015; Proulx & Reid, 2006). It seems the natural inclination of people is to require a definition of a situation before responding to an alarm. They require clarification of the intrinsically ambiguous stimulus. For this reason, people tend to wait for other environmental indicators, for example the smell of smoke, the screams of a wounded person, receiving or seeking information from others, before moving. This time has been defined as 'pre-movement'. Research on two historical fires, the Cocoanut Grove Dance Hall in Boston in 1942 and at the Beverly Hill Supper Club in Southgate, Kentucky in 1977, have shown how this time and the related behaviours are decisive for the outcome of an evacuation (Johnson, 1988). Proulx's work suggests that the pre-movement time is on average longer than that used to reach the escape routes and that it is within this phase that the emotional and pragmatic conditions influencing the entire evacuation phase are determined (Proulx, 1994, 1995). In this pre-movement phase people are basically dealing with three orders of problems. Firstly, the perception of the alarm signal, or cue. This is followed by a need for its validation through the search for adequate confirmations. Finally comes the decision as to what to do.

The need to carry out an evacuation is determined by the acceptance that a potentially dangerous situation is taking place, or may develop, and that people in the environment perceive it. The perception of danger can be directed to the extent that the person perceives the presence of a source of danger. This might be the sight of flames and simple smoke. However, people in a crowd tend to be instructed of a dangerous situation by an alarm signal. The sounding of an audible alarm signal will create different perceptions and reactions between different types of participants. Habitual visitors to the environment, for example employees, will attribute a different meaning to the alarm than occasional visitors, for example customers of a supermarket or spectators (Proulx, 2007). For the former, assuming awareness of a known and shared emergency plan, the alarm and evacuation signal has a precise pragmatic meaning. For the latter, the alarm exists only as a signal without specific meaning or consequence, and which perhaps might also not be sufficiently distinguishable from other unfamiliar sounds in the area. It has previously been shown that people tend to think that the probability that the alarm corresponds to a real event, and that it can pose a danger to them, is extremely low (Quarantelli, 1991). It is the ambiguity contained in the danger and emergency indicators that pushes people to seek confirmation of what has been perceived. The search for further information is all the greater for people occasionally present in the environment or when the path to evacuation appears long and complex.

Social aspects play an important role in human behaviour, especially in emergency situations. These social aspects concern the effect that the behaviour and attitudes of some have on the behaviour of others (Hewstone & Martin, 2008). The research carried out suggests that the most sought-after sources of information are friends and relatives (Sorensen & Mileti, 1988) and building staff (Brennan, 2000), even more so if identified as emergency workers (Carrolo et al., 2006). The importance of this additional information calls into question both the information system provided by the evacuation plan, in terms of audio messages supplementary to the simple request for evacuation, and the role of the staff, whose attitudes and whose answers can be decisive in these situations. Social influence can have both positive and negative effects on the outcome of the evacuation. For example, observing others who are preparing to evacuate can increase the observer's perception of risk and propel them to prepare for their own exodus. However, the inverse situation may have adverse effects. For example, if a person with a high perception of risk looks around and sees others calm and collected, they may consider their own feelings to be an overreaction and consequently delay protective action and ultimately evacuation (Kinateder et al., 2015). Social aspects are also fundamental in confirming the emergency event. In addition, research confirms that the higher the perceived risk, the more likely it is that the confirmation process will activate quickly (Mileti & Fitzpatrick, 1992; Nylen & Hultaker, 1987).

In the initial moment of an emergency event, people tend to seek comfort, information, and to reunite with loved ones, or members of their group (Mileti & Fitzpatrick, 1992; Richardson et al., 2019). The search for confirmation from friends or relatives recalls another variable inherent in pre-movement behaviours: the presence of people. If, on the one hand, a reassuring picture is provided, evacuation time is extended because people are inclined to seek out those with whom they are affiliated before deciding to leave the building. Individuals within the crowd who are a part of family groups or friend groups tend to evacuate together and generally try to convene before escaping (Aguirre et al., 1998; Cornwell, 2003; Johnson, 1988). The term ‘milling’ was developed to indicate social interactions in early alarm phases (Aguirre et al., 1998). It signifies that individuals evaluate and seek confirmation with other people regarding the severity of the message or the warning they received. It is only once the social network has confirmed the validity of the warning that preventative and protective actions are performed (SFPE, 2019).

Familiarity with the environment has also been found to affect evacuation behaviour (Nevalainen et al., 2015). This includes knowledge of escape routes and alarm signals, the possibility of personally seeing the escape routes, the presence and location of truly perceptible signage and past experience of emergency situations and drills. However, this is not necessarily advantageous. People are more likely to search for known locations even when it entails additional risks (Bryan, 1999). This means alternative route choices and emergency exits might not be taken into consideration when individuals can take their 'normal' path (Mawson, 2005). Moreover, it was suggested that social norms and group behaviours are likely to persist, and, for example, escape route choices will be affected by the choices observed in others (Aguirre, 2005; Canter et al., 1980; Lo et al., 2004; Richardson et al., 2019; Zhao et al., 2006, 2008). On the other hand, research data does not unequivocally indicate the inability of people to subvert normal behaviour, for example carrying personal items, such as bags, with them. As Kuligowski and Mileti (2008) observed, examining this issue within the evacuation of the World Trade Centre, the higher the perception of danger resulted in the lesser the tendency to deal with personal items.

The pre-movement phase is influenced by various individual factors such as role and responsibility, commitment, levels of stress-management and self-efficacy (Day et al., 2013; Gershon et al., 2007; Kuligowski, 2015). With respect to role and responsibility, a social role can be extremely significant in an emergency, especially if associated with authority and trained staff. It has been demonstrated that most people take on a subordinate role (Averill et al., 2005; Cornwell, 2003) and are inclined to wait for others to make decisions about the behaviours to adopt. In a hotel emergency, we would expect guests' decisions to be influenced by their subordinate roles, waiting for a staff member to provide specific information and instruction (Canter et al., 1980). In terms of commitment, people are in a specific environment for a reason. Individuals who find themselves involved in an emergency were previously engaged in activities such as eating at a restaurant or attending a theatrical performance. The commitment to a specific activity can continue after the reception of the first indications of the existence of abnormal conditions. This may delay the processing of environmental cues (Dowling, 1994; Sime, 1983, 1984). The level of stress-management is a function of threat. The dangerous situation exposes the person to several stimuli of a certain quality, which may significantly increase the feeling of stress. This may reach such a level that it significantly compromises cognitive processes, relating to both perception of what is happening and decision-making (Proulx, 1993).

Finally, all beliefs are moderated by a sense of self-efficacy (Benight & Bandura 2004; Demuth et al., 2016). Bandura (1996) defines this as the conviction of one's own ability to organize and carry out the necessary actions to adequately manage the situations that will be met in a particular context, in order to achieve the established goals. This is an important feature in emergency situations because, with the same intelligence and specific abilities, a person with a stronger sense of self-efficacy will have different objectives (Newnhan et al., 2017). Theoretically, they will choose higher goals, be more motivated, use their skills more efficiently, suffer less anxiety, manage failures better, be more tenacious and, in the end, obtain significantly more satisfactory results than those who have a low sense of self-efficacy and a negative perception of their own possibilities.

The quality and accessibility of communication is of fundamental importance for the interpretation of what happens during an emergency situation (Cocking & Drury, 2008; Drury & Cocking, 2007). Warning and evacuation communications need to be authoritative, clear and effective. They must include precise and understandable instructions in order to direct the crowd towards a safe evacuation (Ciallella et al., 2018; Cocking & Drury, 2008;

Johnson & Feinberg, 1997; Johnston & Johnson, 1989; Ripley, 2005). Providing as much actionable information as possible promotes a more effective crowd response during emergencies (Proulx & Sime, 1991; Wessley, 2005). Conversely, providing incomplete information may promote a collective feeling of distrust. This may be directed towards reference figures and the authority responsible for managing the emergency, resulting in less effective evacuation operations (Drury & Cocking, 2007). Therefore, emergency warnings must be specific, precise, comprehensible and descriptive of the nature of the problem in order to aid the crowd in perceiving and interpreting cues correctly. Delaying the alarm or inviting the crowd to remain calm as a strategy to avoid panic itself is likely to result in the opposite effect. By delaying evacuation operations, an increase in the activation of anxiety and fear within the crowd occurs, thus increasing the likelihood of evacuation complications (Durodie & Wessley, 2002; Mawson, 2005; Sime, 1995, 1999).

That there are optimal ways through which to promote effective crowd action is well evidenced. Crowds seem to act in a rational way, and if trust is nurtured through clear and actionable instructions, guidelines will be followed (Ciallella et al., 2018; Cocking & Drury, 2008; Drury & Cocking, 2007). Yet, this is due to an acceptance of authority and recognizing that hierarchies evolve with respect to different types of participants. This demonstrates that, even though a crowd may be defined in one of many ways, any crowd is not entirely homogenous. Furthermore, this heterogeneity is not simply a function of authoritative hierarchy. Individuals remain individuals, even when part of a crowd. Therefore, personal traits are equally responsible for the outcomes associated with participation. It follows that the role of individual differences must be assessed in relation to emergency evacuations.

2.3.1 Specific Variables of Interest

Different variables have been identified as important components in evacuation behaviour in several disaster types. These variables have been identified by Riad et al. (2001) as either stable variables, meaning variables that have been found to be relevant across a consistent number of studies, or unstable research findings, meaning results which vary across different studies. Gender, family and prior experience were reported as stable variables, whilst age was considered an unstable element.

Gender.

Gender may be considered a stable variable as differences have been found in evacuation behaviour in different types of emergencies (Riad et al., 1999). Psychological literature supports the notion that women tend to have a higher risk perception, to perceive threats as more serious and to believe warning signs to be valid compared to men (Bateman & Edwards, 2002; Cahyanto & Pennington-Gray, 2015; Cutter, 1994; Fothergill, 1996; Hung, 2018; Kuligowski et al., 2017). In hurricane evacuation studies, it has been found that women were more likely to receive risk communications, prepare for evacuation and to respond to threats with protective actions (Fothergill, 1996; Riad et al., 1999). In a study of human behaviour in fires, Canter et al. (1980) found that differences in behaviour between males and females occurred through different stages of the emergency. Initially, males focused on seeking information more than females, but once the emergency situation was established, females tended to warn others and seek help, whereas males were more likely to fight the fire and help others. Possible explanations for gender differences, especially in risk perception, could be attributed to socio-political attributions rather than gender in terms of biological factors (Shiwakoti et al., 2020). However, recent generations have experienced a shift in gender roles and perception. It is therefore of interest to investigate whether the discussed gender differences are still present today (Al-Rousan et al., 2014).

Age.

Age was considered to be an unstable variable (Riad et al., 2001). It has, however, been found to be a factor impacting both evacuation time and overall behaviour in evacuations in some studies. In research conducted by Jeon et al. (2014), which concerned evacuation behaviours in a subway station in South Korea, it was found that age had an impact on both evacuation speed and time. In another study, it was found that during emergency situations younger individuals tend to seek information more than elders, whereas elders spent more time assisting others (Friberg & Hjelm, 2014). Nonetheless, further studies on age differences in evacuation responses and risk perception were inconclusive (Day et al., 2013; Howard et al., 2017; Mayhorn et al., 2002; Thompson et al., 2018; Thompson et al., 2016).

Family.

Family variables have been identified as stable over different forms of evacuation (Drabeck & Stephenson, 1971; Moore et al., 1963; Riad et al., 1999). Families tend to evacuate as units, to search for members and reunite before taking the decision to evacuate as a whole (Cutter & Barnes, 1982; Drabek & Boggs, 1968; Perry, 1979; Smith & McCarty, 2009; Tiernay et al., 2001; Wang et al., 2020). In their study of the Denver flood in 1965, Drabeck and Stephenson (1971) found that when family members were separated, their initial concern was finding the others, and only later evaluated evacuation. Recent studies in building fires and maritime evacuations (Casareale et al., 2017; Mawson, 2005; Ockerby, 2001; Wang et al., 2020) support the notion that people entering a setting together, as a group, tend to focus on reuniting and only evacuate once they are wholly regrouped.

Furthermore, having children can also affect evacuation behaviour. Families with children may consider evacuating regardless of their individual perception of the risks but driven by concerns for their children (Kirschenbaum et al., 2005; Turner & Oakes, 1986).

Prior Experience and Evacuation Knowledge.

Previous experience has been found to affect evacuation behaviour (Gershon et al., 2007; Kinateder et al., 2015; Proulx, 1993; Rando et al., 2007; SFPE, 2019; Wachinger et al., 2013). In evaluating hurricane threat and evacuation intentions, Riad et al. (1999) found that individuals who had previous experience were more likely to consider evacuation, were more prepared and reported higher risk perceptions. Till and Babcock (2010) analysed human behaviour during a building evacuation focusing on differences between test subjects with previous experience in building evacuation and those without. The results revealed that subjects with previous experience were able to evacuate faster than others. Similarly, during the evacuation of the World Trade Centre in 2001, individuals who had experienced and survived the 1993 bombings were found to have quicker and more efficient evacuations compared to other occupants (Day et al., 2013). Having prior evacuation experience implies that individuals have a stock of behaviour related to emergency response. What is known from previous experience will influence a person's understanding and reaction to a similar situation. However, previous knowledge could influence coping strategies by both increasing and decreasing evacuation effectiveness (Currie, 1985). In view of the fact that emergencies can never be exactly the same, effective behaviour in a certain emergency might not result in effective evacuation response in a different situation. Due to the complex nature of disasters, it is crucial to analyse context differences while attempting to identify universal evacuation predictors (Quarantelli, 1984). Being involved in a disastrous event is not an experience that falls within daily human experiences thus implying that most of the people involved are likely to be unprepared for evacuation procedures. It is for this reason that people tend to normalise emergency situations and try to behave as if the situation is normal thereby delaying evacuation (Donald & Canter, 1992; Proulx & Reid, 2006). Evacuation simulations are thus necessary; appropriate preparation for emergency evacuation operations increases the speed and the ability of individuals to react and respond resulting in more effective evacuations (Drury & Cocking, 2007; Fahy & Proulx, 2002).

The variability of the factors presented confirms the notion that we must work towards an emergency system rather than an emergency plan. The former being an instrument capable of adapting to changing situations unlike the latter which appears far too static to address the issue of human behaviour in such circumstances.

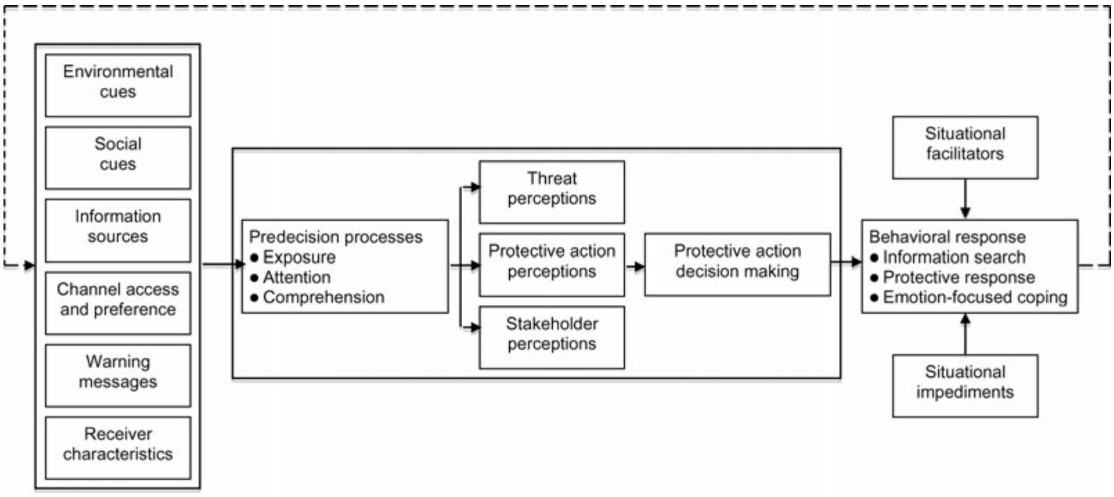
2.4 Behavioural Models and Frameworks

A general model of behaviour was proposed by Canter (1980) following investigations of human behaviour in different residency fires. Three main stages were identified: interpret, prepare, and act. The 'interpret' phase is initiated following the preliminary cues of a hazardous situation. It involves the reception, perception and interpretation of the cues. Canter (1980) notes that the ambiguous nature of initial cues may lead individuals to ignore them and continue engaging in their normal activities or to investigate and engage in information seeking activities. The 'prepare' phase consists of different behaviours that were simplified into the following three categories: instruct, explore and withdraw. 'Instruct' involves the relaying of information and instructions and to provide reassurance to others. 'Explore' involves searching for more cues and information. 'Withdraw' involves returning to a space previously considered safe. It can be argued that it is within this overall phase that occupants engage in their first rounds of cognitive evaluation. It's important to note that this phase can be strongly influenced by the type of scenario being investigated and the social roles and rules characteristic to the context (Canter, 1980).

Finally, the ‘act’ stage initiates when occupants begin to adopt physical actions aimed at ending the event, for example to fight the fire, leave the environment of the dangerous situation, warn others to evacuate and wait to be rescued.

Lindell and Perry (2004, 2012) developed a decision-making model based on years of research on disasters and various theoretical perspectives found to influence disaster response: the Protective Action Decision model. The model, graphically represented in Figure 4, sequentially describes the different factors influencing behaviour response and decision making in disaster scenarios. The process initiates when individuals receive one or more cues that may be either environmental, social, information or observed behaviour of others and warning messages. Following the encounter with these cues, three pre-decisional processes occur: individuals must be exposed to cues, they must be attentive to the reception and must be able to comprehend and understand them. At this stage, individuals become aware of a potentially dangerous situation through their individual threat perceptions and protective action perceptions.

Figure 4. Protective Action Decision Model



Note. Reprinted from Lindell, M.K. & Perry, R.W. (2012) The protective action decision model: theoretical modifications and additional evidence. Risk Analysis, 32(4), 617. Copyright 2011 by Society for Risk Analysis. Reprinted with permission.

The authors, Lindell & Perry (2004) presented the typical questions individuals ask themselves during risk identification and assessment or protective action decision making:

> “1. Is there a real threat that I need to pay attention to?
>
> 2. Do I need to take protective action?
>
> 3. What can be done to achieve protection?
>
> 4. What is the best method of protection?
>
> 5. Does protective action need to be taken now?” (p.29)

The numerous behavioural theories affecting this stage have been previously discussed in section 2.2.1. However, the implementation of the decision-making results is not as straightforward as simply answering these questions suggests. The complexities of an emergency situation often lead to the need to reassess decisions. The assessment of the chosen responses implies the search for further information, its evaluation, and the development of new behavioural responses or emotion-focused coping strategies. Furthermore, situational facilitators and impediments affect individual responses. Individuals may take unintended actions or will not be able to take planned actions based on both physical and social environmental conditions.

Galea's et al. (2015) framework of behaviour in building evacuations describes the required safe egress time (RSET) as consisting of two main phases: response and movement. The response phase consists of three different levels: notification stage, cognition stage and activity stage. The notification phase consists of the reception of fire cues by individuals involved. According to Galea et al. (2015) it is believed to initiate when the acknowledgment of cues begins. These cues are usually ambiguous, including unfamiliar sounds, smells or visual perceptions. The cognition phase consists of the perception and interpretation of the cues received. The evaluation of possible reactions occurs during the cognition phase, these may include: The search for further indicators or information. Like the commitment variable described earlier, people may continue engaging in the activities they were committed to until new cues are received. The individuals interpret cues correctly and become aware of the situation immediately leading to the decision to initiate evacuation (entering directly the movement phase).Individuals interpret the initial cues indicating that something dangerous is happening and enter the activity phase. The activity phase involves individuals engaging in information-seeking tasks and action tasks. It is important to note that, because the cognition phase is difficult to define in terms of when it occurs, it is believed to continue during and up until the end of the activity phase (Galea et al., 2012, 2015). Following information tasks, further cognition is expected. New or further information is likely to lead to a reassessment of the possible actions to take. Information tasks only include tasks such as information seeking and information sharing tasks. Individuals may search for new, more varied information from cues or others. They may provide information to others, and they may discuss the information available with others in order to make better-informed decisions of action. Action tasks consist of physical movements undertaken by the individuals, for example moving towards different physical locations to fight a fire and gathering personal objects. The main difference between information and action tasks within the activity stage is that while information tasks may also include physical movement, their final objective is directed towards obtaining new or further information. The end of the response phase can be defined by the action task representing the decision to evacuate and move away from the dangerous situation, either by exiting or by reaching a safe location (Galea et al., 2012).

2.5 Evacuation Modelling

In recent times, research into the behavioural characteristics of individuals and groups has allowed the development of models to support engineering assessments of the fire safety of buildings. These are based on the comparison between the time required for the exodus and the time available for reaching a safe place (Babrauskas et al., 2010). This concept is now known globally with the formulation ASET > RSET and must include both the physiological response to the products of combustion and the evaluation of the mental mechanisms that govern the emergency behaviour of people (Fahy & Proulx, 2005).

Evacuation simulation software essentially falls into two categories: those that only consider the movement of agents and those that attempt to consider behaviour as well as movement. The first category focuses attention only on the ability to transport its components in the structure. They are referred to as ball bearing models, treating individuals as objects that automatically respond to external stimuli, abandon the structure, and immediately cease other activities (Sime, 1999). Moreover, direction and speed of exit is determined through physical considerations only. A model of this type ignores the individuality of the population, dealing exclusively with their mass exit (Takahashi et al., 1989). The second category of model considers the physical characteristics of the space and treats the individual as an active agent considering both the response to external stimuli and individual behaviour.

For a mathematical model to be useful for informing training and preparedness, it needs to be founded upon a comprehensive conceptual model. This conceptual model needs to be built up from well-supported theories in behavioural and social psychology concerning the prediction of how people act in emergencies. The ultimate aim of such a model is to accurately and comprehensively simulate human behaviour (Santos & Aguirre, 2004).

Currently, the majority of models developed concern building evacuation due to fires (Kuligowski, 2011a, 2011b; Ronchi et al., 2019). It is one of the aims of the present thesis to accelerate understanding of maritime evacuations to achieve parity with this level of modelling. Fire evacuation models are individually focused on how people move during evacuation, specifically represented by speed and flow (Santos & Aguirre, 2004). Similar data was extracted for the World Trade Centre evacuation (Galea et al., 2008). Yet, such calculations are incomplete without combining these rates of evacuation with an understanding of the course of evacuation. The risk exists that only assessing mere exit-speed will lead to under-estimations of evacuation times, which in turn will impact on precautions and preparedness (Gwynne & Hunt, 2018).

In order to address this issue, certain behavioural facts are included in models. One such fact is that people tend to feel comfortable in their environment (Kinsey et al., 2018). There exists a normalcy bias, which upon initiation of a hazardous event convinces people that they are safe and secure (Gwynne, 2012; Gwynne et al., 2015; Kinsey et al., 2019; Quarantelli, 1991). This bias can have an impact upon response to ambiguous cues. Other such facts include rationality, information-seeking, preparation, and familiarity (Kinsey et al., 2019). However, when applied as inputs to calculations, these facts remain isolated and discrete without a comprehensive model to explain behaviours. Therefore, the predictive ability of the user becomes more important than that of the actual model.

Amongst the current evacuation models that include behaviour, three main typologies can be identified (Kuligowski et al., 2010). The first type of model including behaviour takes into account the time individuals spend engaging in activities before physically initiating evacuation (e.g., EXIT89, Simulex). As previously discussed, existing literature has demonstrated that individuals engage in various activities (Kuligowski, 2013). However, this model does not account for the specific actions being undertaken or the complexities of the behavioural process during this time. The model user can assign specific time delays to agents, which in turn will be modelled as 'stationary' until commencing movement aimed directly at evacuation. This type of model is therefore problematic as it oversimplifies the behavioural process and is not capable of accurately predicting behaviour. Another method of modelling includes behavioural aspects by assigning specific actions or sequences of actions to agents (e.g., EXITT, CRISP). Unlike the previous method discussed, this type of modelling includes actions and behaviours identified as part of the overall behavioural process, for example searching for and assisting others. These actions, and the time assigned to them, are however defined by the user and do not include possible interactions with other agents, raising similar doubts as the first method as to its predictive value. Recently, sub-models of behaviour have been included in a third category of evacuation models (e.g., buildingEXODUS). This consists of models including environmental cues and their effect on agents' evacuation strategies. Environmental cues include smoke, flames, emergency warnings, and access and visibility of evacuation signage. Behavioural sub-models allow the model to be more predictive, however it assumes that every agent will react to the same cues in the same way. The assumption that everyone receives, perceives and interprets cues in the same way oversimplifies behavioural processes during emergency evacuations thus rendering this type of evacuation modelling flawed. Similarly, there is an inability to describe the organic creation of new behaviours as parts of a group set out in Emergent Norm Theory (Aguirre et al., 1998).

2.5.1 Creating a Comprehensive Model

As implied by the title, a comprehensive model requires attention to a multitude of variables. Over the years, conceptual models have been developed for human behaviour in disasters (Canter et al., 1980; Kuligowski et al., 2015; Lovreglio et al., 2019; Perry, 1979). These models consider such wide-ranging variables as ethnicity, locus of control, and family context (Perry & Mushkatel, 1984). However, each variable will be of different importance in varying scenarios. Thus, any comprehensive model needs to include not only all relevant variables, but also the weight of influence each variable has on behaviour.

As discussed, it is not simply a rate of egress which is required, but also an understanding of the reasons for choosing certain methods of egress. Therefore, any quantitative model must take into account any qualitative differences between evacuees. In recent years, the Multi-Agent Systems approach has become dominant in research into crowd movement (Pan et al., 2007). In this approach, each person's characteristics are critical. Certain attributes, such as speed, reaction time, and collaboration are modulated by extensions including gender, age, experience, and role (Fangqin & Aizhu, 2008).

2.5.2 Discovering the Weight of Extensions

Most models focus on the rate of movement from initial cues to evacuation (Gwynne et al., 2016). Certain non-movement behaviours, for example information gathering and alerting others, may be considered inefficiencies in this rate of evacuation. Thus, it becomes important to establish not only the duration of these inefficiencies, but also whether certain attributes or extensions of an agent lead to a tendency towards certain rate-inefficient behaviours (Galea et al., 2007). Furthermore, these tendencies may be different for different categories of agent during the different phases of evacuation. Finally, agents forming groups or encountering agents with greater experience may further modify these tendencies (Aguirre et al., 1998; Lovreglio et al., 2019). Ultimately, once tendencies are identified, it will become necessary to perform types of regression analysis. However, to state these tendencies with any confidence, the initial step towards predicting the behaviour of humans in emergency situations is to investigate how different categories of people firstly interpret cues and secondly react to them.

2.6 How do People Behave in Maritime Emergencies?

To this date, little real-life data on human behaviour in maritime emergencies is available. Architects, operators and regulators primarily use accident reports and evacuation models and simulators to take important decisions regarding maritime safety. Investigation reports including passenger data are quite rare and mainly focus on more technical aspects of the accident. As previously discussed (see section 2.5), the available models tend to be generic in regard to human behaviour and do not take into specific consideration important actions such as information processing and the processes of decision-making. Furthermore, the beginning of evacuation behaviour is set as the moment an alarm is sounded, excluding important aspects of the emergency. Including human cognitive abilities in evacuation modelling is crucial, yet access to data is extremely limited. The ability to create reliable data for rigorous analysis is an overarching aim of the present thesis.

The Manual for the Cruise and Ferry Sector, Understanding Human Behaviour in Emergencies (Poole & Springett, 1998), discusses passenger behaviour during evacuations at sea. The intention of the manual is to assist seafarers in managing passengers during emergencies. However, the concepts discussed are not evidenced by detailed investigations.

The manual divides evacuation into four phases: alarm, impact, evacuation and rescue. However, these phases can be argued to not respect the real timings of possible events of an accident. There are several dynamics that could intervene, which could suggest different intermediate phases and their interdependency. For example, the alarm phase could start when the captain sounds the alarm, yet it could also start when passengers realise something is happening in the environment and consequently react. Similarly, the alarm phase can be understood as the moment in which the captain and the officers evaluate the event and decide to notify an emergency. Within this phase, the time required to sound the alarm and to prepare passengers for evacuation should also be considered (Lindell & Perry, 1992; Rogers, 1994). The evacuation phase is believed to begin with lifeboat embarkation operations when the crew is ready and present at their assigned locations. However, crewmembers are usually warned in advance through private radio communications. Therefore, the moment at which staff members become aware could be considered as the actual start of the evacuation phase. Furthermore, regarding the impact phase, defined as the moment at which the event occurs, and the moment at which participants understand they are involved in an emergency, might not coincide. The accident event and the realisation of what is happening should therefore be considered as two distinct moments in a potential evacuation model. Poole and Springett (1998) recorded several assumptions on how people behave during maritime emergency situations:

- Passengers will behave optimally when given instructions by crewmembers, yet only if there is trust in the crew and their abilities. Crewmembers will react more efficiently while passengers will require several signs before realising that there is a problem. Hearing an alarm will not suffice in alerting passengers, the correct interpretation of a dangerous situation takes time and people will only move once the motivation to do so is informed by the knowledge that they are in danger and need to escape.

- Group dynamics will affect the way people move. Passengers will observe the movement of others and follow them.
- Signage, such as emergency maps and exit signs, have little impact on evacuation time. Emotionally charged passengers are likely to lose sight of peripheral cues.
- Not everyone will be able to evacuate in the same way. Age and previous experience will influence evacuation behaviour.
- The unknown nature of the emergency situation will affect passengers' abilities to react. Without assistance and clear instructions, passengers are likely to become helpless, scared, and stressed. They estimate that only a few individuals will react rationally, about 25% of the passengers. When clear information is not available, panic behaviour is expected to occur.

These behavioural assumptions proposed by Poole & Springett (1998), whilst being indicative, are lacking empirical research to back them up.

The MEPdesign project, funded by the EU, examined the total time required for the evacuation of RORO Passenger ships, comparing the results of simulation software EVAC to the recorded observations during real evacuation drills at sea (May, 2001). The analyses were conducted taking into consideration the following aspects of human performance: reactions to alarms, way finding, group binding, resistance to following instructions and panic. The behavioural theoretical assumptions were examined, and conclusions provided advice and recommendations to facilitate assembly and evacuation phases through improving assembly routes and emergency signage. Psychological aspects such as the fear of the unknown and environmental familiarity were found to cause way finding errors. Group binding was found to delay evacuation, as passengers were concerned with finding relatives or other group members. It was also predicted that individuals will not follow instructions before regrouping. They will either wait in a pre-defined location or move to different locations searching for group members. During the drills, some passengers actively searched for information about their groups from crewmembers. While evacuation times were simulated accurately, the author reported issues with simulating the behavioural assumptions due to lack of data and clear knowledge of behavioural processes during evacuations at sea. It was concluded that a re-evaluation of the behavioural assumptions made by Poole and Springett (1998) was necessary (May, 2001).

With the goal to advance knowledge in maritime evacuations, the EU Framework Programme 7 project SAFEGUARD conducted five trials at sea, on RoRo Passenger ships (with and without cabins) and a cruise ship (Galea et al., 2013). Sea trials are a relatively new method of research. Previously, drills and experiments had generally been conducted in port settings (Galea et al., 2013). Passengers on board were told there would be a drill but were not told the exact time. Data were collected through videos captured by cameras installed throughout the vessels, IR tag systems, and post-trial questionnaires. This type of data collection allowed for the analysis of passenger response times and route and exit choices. Unlike normal drills, the indicated drills were able to provide a better understanding of required evacuation times. The results reported differences between expected time and effective time of evacuation and differences between RoPax vessels and cruise ships. Furthermore, accident-related factors such as the listing or heeling of a vessel can gravely impact behaviour during evacuation (Lee et al., 2003; Sun et al., 2017). These examinations were conducted in optimal conditions and do not account for such factors. In this regard, the analysis of the 1995 St. Malo passenger ship demonstrated that while the total time reported during a standard drill in normal conditions amounted to eight minutes, the real total evacuation took more than one hour (Lockey et al., 1997). During the project, SAFEGUARD lab simulations were run to evaluate ship trimming and heeling effects on response times. Though results demonstrated an increase in assembly times, the simulations should not be considered representative of large ship scenarios. The results of the sea trials were validated through the running of maritimeEXODUS software. Even though passengers' behaviours and responses were recorded through questionnaires, no detailed analysis aimed at investigating psychological aspects was conducted. This dataset represents a unique opportunity to further develop correlations between passenger characteristics provided in the questionnaires and the routes and assembly time performance for the associated IR tag data. It is potentially valuable because it connects assembly performance to personal data and should be analysed in detail to determine what correlations exist. The results from such investigation should be made publicly available to regulators, designers and modellers. Galea et al. (2013) stated that these trials were a step towards a more real representation of evacuations at sea. Investigating and improving our knowledge of passenger behaviour would therefore be a further step.

Considering the lack of thorough analysis of human behaviour during maritime emergency evacuations, the use of behavioural models in other emergency scenarios becomes necessary. Even though similarities in the two environments can be found (Galea et al., 2013), differences concerning vessel layout and specific environmental factors are present and imply the necessity of a conceptual model. Understanding that there may be inaccuracies in remembered accounts (De Vita, 2011; Talarico et al., 2009; Wood, 1980) casts doubt on the veracity of real-life data collected in good faith. If this is the case, it is potentially more effective to redirect current methods away from the analysis of imperfectly remembered acts towards understanding the motivations which affect decision-making.

The Talk-Through Method.

The Talk-Through method (Kirwan & Ainsworth, 1992; Lawson, 2011; Lawson et al., 2009b) collects data from participants' accounts of their predicted actions in a particular scenario. It is intended to provide a similar form and granularity of data to that provided in real-life accounts for use in sequential analysis. It is a low-cost method which may be conducted with minimal risk. Its value lies in its potential ability to produce reliable data for an area, which currently suffers from a scarcity of resources. It may also be adapted to examine any specific type of scenario. The method involves the creation of an environment to be imagined by the participant. The participant is then requested to recount the acts they would undertake, in order, from pre-event activity to end of involvement. If accounts lacked certain detail, participants were guided towards expanding upon them by the researcher.

Lawson (2011) reported high statistical similarities between hypothetical and real-life acts both in terms of frequencies and sequences. However, questions were raised concerning validity in the absence of threat and the associated heightened emotions. Furthermore, it was acknowledged that the current state of the methodology is no more enlightening for sequence analysis to determine motivations behind actions. It was suggested that results obtained could inform computational models of predicted actions based on probability. However, again, this is no more enlightening than the use of simple artificial intelligence or crowd phenomena in existing behavioural models (Gwynne et al., 1999; Pan et al., 2006). One of the problems for which the present study aims to provide a solution is to transform such probabilistic descriptions into more realistic behaviour. Human behaviour is guided by qualitative and quantitative motivations dependent on characteristics of the participant and the evolution of groups within which they may function. The ability to accurately incorporate these factors is necessary for the creation of a compelling evacuation model (Kuligowski et al., 2017).

The study concluded that the Talk-Through method was able to provide indications of predicted behaviour in emergency scenarios (Lawson, 2011). It was also suggested that the method demonstrated certain validity, reliability, and generalisability. A commonly reported issue concerns the ability to ethically examine evacuation behaviours (Galea et al., 2007; Gershon et al., 2007). As a low-cost, minimal risk form of data-collection, the Talk-Through method may provide a solution to the scarcity of reliable data in this field. An intention of the present study is to assess the ecological validity of the method. This was specifically noted as a gap in knowledge (Lawson, 2011). Ecological validity will be assessed through the comparison of data collected from real-life accounts with data collected via the Talk-Through method. It is anticipated that the results will show similarities. However, if inconsistencies are revealed, it will be further considered whether improvements are possible. The aim of this part of the present study is to provide evidence which may accelerate the production of reliable data for examination in research concerning disaster evacuations.

2.7 Integrating Psychological Research and Social Psychology Theories into Computational Modelling

Computational modelling relies upon mathematical formulations (Seitz et al., 2017). With respect to evacuation scenarios, such models are created for the purpose of predicting crowd behaviour. In order to design, calibrate, and validate these models, there must be a supply of high-quality quantitative empirical data (Bandini et al., 2014). However, there is a limited supply of such data from emergency situations. It is this problem which the current project is focused on providing a solution to. The two main types of computer simulation are macroscopic and microscopic. A macroscopic model examines the overall flow of a predetermined crowd, while a microscopic model focuses on the behaviour of the individuals which form the crowd. Similarly, psychology suggests there to be two types of crowds: physical crowds and psychological crowds (Neville et al., 2020; Reicher, 2011; Reicher &

Drury, 2010; Turner et al., 1987). A physical crowd is simply a collection of individuals, whereas it has been asserted that psychological crowds exist which share a group identity, which affects behaviour (Neville et al., 2020; Reicher & Drury, 2010). However, it has also been suggested that such crowds may form dynamically, indicating an individual’s ability to choose to become part of a group or not (Drury, 2018). The way an individual puts such choices into action may be considered discrete acts in a sequence of behaviour. This would suggest microscopic models of individual behaviour should be the building blocks from which models of crowds are created.

Microscopic models simulate the behaviour of an individual agent (Seitz & Köster, 2012). However, the underlying drivers of the simulated behaviour focus on flows and speed of movement are not necessarily aimed at replicating human cognitive decision-making (Moussaïd & Nelson, 2014). A possible route to informing these underlying drivers is through the incorporation of quantitative representations of cognitive heuristics (Seitz et al., 2017). This would allow for the modelling of changes of states of individuals, not only in their individual decision-making, but also their potential membership of a psychological crowd. According to Burstedde et al. (2001), the most appropriate form of computational model to accommodate these state-changes is a probabilistic cellular model. In such models, the direction and speed of an individual are considered in terms of steps between cells which may be occupied by a single agent. Motion may be optimised through perceptual cues (Moussaïd & Nelson, 2014). Additionally, it would be possible to affect motion through a probabilistic representation of the drivers of behaviour gained from examination of act sequences in evacuation scenarios. This may be further expanded by evaluation of differences in acts dependent on the traits of an individual and their potential membership of psychological crowds. Eventually, these building blocks may be combined to create a data-driven combined computational and psychological model of human behaviour in evacuations.

Evacuations are phenomena that affect a large number of people simultaneously (Quarantelli, 2001). Computational modelling, and particularly cellular models (Seitz & Koster, 2012), would view each individual as an agent probabilistically moving between locations in order to effect evacuation. This computational view of crowds is consistent with the view that any psychology of crowds is a combination of the individuals' psychologies (Allport, 1924). However, more recently, theories have evolved which attempt to explain the behaviour of multitudes of individuals in terms of the crowd they form. It has been suggested that mass emergencies not only happen to crowds, but also create crowds (Drury, 2018). Such 'psychological crowds' are purported to be created spontaneously through transformation of social relationships based on the concept of social identity (Neville & Reicher, 2011). Furthermore, it has been suggested that the motivational foundation for the adoption of a shared social identity is the concept of a sense of common fate (Drury, 2018).

The present thesis exists as a qualitative reconstruction of a real-life disaster. It is also concerned with validating a method involving imagined behaviours, which could lead to the production of data of sufficient quality to be integrated into computational modelling of evacuations. It is possible that evidence may become apparent for certain claims of theories based on social identity. One such claim is that the alleged widespread helping of others (Grimm et al., 2014) is a socially motivated behaviour which conflicts with the individualistic motivation for self-preservation (Fairclough, 2013). Mass emergencies are defined as situations in which there is a limited opportunity to escape or in which there are limited resources (Quarantelli, 2001). Therefore, it would seem helping others is a maladaptive act which depletes personal opportunity and resources such as time and energy.

Previous studies concerning the World Trade Centre evacuation reported widespread cooperation and social support (Averill et al., 2005). It was proposed that social norms overcome self-preservatory motivations in terms of behaviour. There is evidence for those with pre-existing ties to gather before effecting evacuation (Cornwell, 2003). It is further suggested that such ties and solidarity may emerge with strangers through the concept of 'emergent groupness' (Jong et al., 2015; Paton & Irons, 2016; Walker-Springett et al., 2017). This concept is similar to that proposed in social categorisation theory (Turner, 1982, 1985; Turner et al., 1987, 1994) which suggests that the fundamental root of collective behaviour is a shared social identity.

However, it has also been accepted that physical crowds may consist of many, some, or even no psychological crowds (Reicher, 2011). In certain situations, the 'crowd' may be easily delineated, for example those trapped within a rail carriage (Drury et al., 2009). In other studies, the 'crowd' is more fluid and potentially more expansive than is comprehensible (Reicher, 1984). Similarly, there are issues in the description of 'crowds' acting 'as one'. This concept of 'as one' is further confused through definitions including 'coordination' (Connell, 2001). Of main concern when attempting to integrate recent theories of social psychology is a lack of delineation between types of, and moments within, emergency scenarios. It has been noted that individual competition overcomes social norms in escape emergencies (Frey et al., 2010). Conversely, evidence of widespread helping seems to be drawn predominantly from studies where, in hindsight, there was no further threat (Chertkoff & Kushigian, 1999; Rodríguez et al., 2006). This contradiction may suggest that an alternative explanation for helping behaviour is that individuals inclined towards pro-social behaviour are also inclined to under-estimate risk. Such an explanation could be examined using individual-focused, data-driven, computational-modelling appropriate psychological research.

2.8 Summary

Efficient evacuation in emergencies is affected by many factors. The type of emergency, environment and severity are of primary significance when assessing the impact of a disaster. However, it is in the nature of a disaster to be unpredictable and potentially uncontrollable. Certain tragic scenarios will afford no opportunity for evacuation. It is perhaps partly for this reason that research into evacuation is so scarce, especially when investigating the primary resource of those involved. There may be an unwillingness to recall events, which may be coupled with the ethical issues of asking an individual to relive a potentially terrifying ordeal. There is also the inescapable, and possibly morbid, fact that it is impossible to access testimony from those who were unable to evacuate (Gershon et al., 2007). However, even though the type of emergency and environment will exist as categorical variables, the severity of disasters exists on a scale. It is the responsibility of scientific investigation to optimise the potential outcomes on every step of that scale.

Some of this optimisation is the responsibility of standards of engineering, safety and duties of care. That a building is less susceptible to collapse, or that there are enough fire extinguishers is an issue for other authorities. It is the responsibility of psychological investigation to promote optimal outcomes by understanding how people may naturally act, and then to introduce interventions through which to encourage individuals and crowds to manoeuvre with greater efficiency. Above all, it seems well-evidenced that, during emergency scenarios, individuals and, by extension, crowds of individuals act rationally (Pan et al., 2006). However, this rationality is modulated by two symbiotic factors: knowledge and emotionality. Additional knowledge improves the effects of rationality, whereas greater emotionality interrupts it, possibly to the point of paralysis. Therefore, the aim of interventions should be to promote self-efficacy through increasing knowledge and understanding of a situation, which will, in turn, diminish the role of emotionality and its interruptive effect on efficiency.

The most effective way to promote self-efficacy during an emergency scenario is through authoritative instruction (Gershon et al., 2007; Lamb et al., 2012; Xia & Gonzales, 2021). At first sight, this may seem counterintuitive. However, evacuation scenarios tend to be crowd activities. Hierarchies are understood quickly in such situations and self-efficacy becomes a part of the crowd-efficacy. People will look and learn from others, and the probabilities become greater that certain members of the crowd are to be followed or emulated. This in turn promotes a greater feeling of knowledge, prevents emotions from becoming overwhelmed, and encourages each individual to become part of a psychological crowd instead of competitive agents (Drury, 2006). This represents the ideal portrayal of the evacuation stage of an emergency. However, in order to achieve this, authority must be constructed and responded to, and beneficial instructions must be formulated and communicated (Cocking & Drury, 2008). Therefore, it must be understood what decisions people make, why they make these decisions, and whether there are categorical differences in decision-making between individuals with different characteristics.

In many ways, the Costa Concordia disaster is an ideal case-study for analysis of evacuation procedures. Although thirty-two people tragically lost their lives, this represents only approximately one per cent of those on board. In those terms, it was a very successful evacuation. Additionally, that criminal proceedings were brought ensured that there were interviews conducted under oath, which informed the resultant transcripts of survivor experiences. Finally, and of greatest consequence to the present study, the disaster was straightforward. The Costa Concordia hit a rock, which tore open the hull. It then listed, ran aground and rolled onto its starboard side. There were no significant intermediate collapses or explosions. The integrity of the ship, besides that of the hull, was sustained. This means that, between the original impact and evacuation, there are minimal confounding incidents which might influence the decision-making of individuals or of different samples of the same population. The data to be interpreted are the decisions of individuals experiencing very similar situations, though perhaps in different ways (Court Technical Report, 2012; MIT, 2013).

That the disaster can be considered straightforward is beneficial to the present study. As there are no significant, novel events to be introduced at critical times, it is easy to reconstruct the event. This would imply that, if purely imagined, the steps involved in decision-making would be similar. Obviously, the emotional reactions would be absent, and it would be ethically unsound to aim to mimic them. However, as one of the main aims of optimising outcomes is to reduce emotionality, this too is perhaps beneficial. As stated, the responsibility of psychological research with respect to the creation of a combined model of evacuation behaviour is to provide an optimised model of human decision-making. The optimisation of decision-making in such scenarios relies on self-efficacy. This self-efficacy may be promoted through authoritative instruction (Gershon et al., 2007; Lamb et al., 2012; Xia & Gonzales, 2021). Therefore, it must be understood what makes people acquiesce to authority, and what is the best form of instruction. This must be studied, but the availability of data from real-life disasters is scarce and ethically problematic. Therefore, it might prove to be a fruitful avenue of examination if we can rely on data gathered from imagined scenarios. However, before it is possible to treat data gathered in such a way as valid, there must be evidence that there are sufficient similarities between real-life versus imagined accounts. If consistent similarities are not found, then it is more productive to formulate a new methodology and set a different direction for the effective research of maritime disaster evacuation.

Chapter Three: The Costa Concordia – Case Study

The following timeline was constructed with information available in the MIT report (2013), the court technical report (2012) and Mastronardi et al. (2014).

In January 2012, the Costa Concordia cruise ship was engaged on a cruise in the Mediterranean called “Profumo di Agrumi” departing from the port of Savona with six stopping points: Marseille (later replaced by Toulon due to adverse events weather conditions), Barcelona, Palma de Mallorca, Cagliari, Palermo, and Civitavecchia. The tour had a one-week duration and was not interrupted, meaning that the ship, once it reached the last port, immediately left with new passengers on board to renew the cruise. On the evening of the 13th of January, at approximately 19:00, the ship Costa Concordia left the Port of Civitavecchia with 3,206 passengers and 1,023 crew members, for a total of 4,229, people on board. The manoeuvre of exit from the port of Civitavecchia took place regularly with the help of a tugboat as required by the maritime authority and the ship should have maintained the direct route Civitavecchia-Savona. However, on that day a detour had been planned to allow passengers to admire the coastal areas. The detour consisted of a “salute” to the coast of the Island of Giglio. This practice is called the ‘inchino’, Italian for ‘bow’. The manoeuvre, carried out near coastal settlements, involved the cruise ship being quickly turned and straightened while sounding its horn as a greeting to those observing from the ground. By deviating from the safe course to bow, ships performing the ‘salute’ enter an area of risk, not always adequately controlled, in which the management methods depend mainly on human factors and the technical equipment available. Two factors may occur: the first is that the overconfidence of the command group moves the line towards the coast more and more, increasing the dangers; the second is that in these situations it becomes difficult to correct any human errors.

During the salute at 21:45 the Costa Concordia impacted with the left aft stern against underwater rocks ‘Le Scole’ a few meters from the coast of the Island of Giglio in the Tyrrhenian Sea. Immediately following the moment of impact there was a blackout and strong vibrations on the ship were perceived by everyone on board followed by rapid turns of the vessel resulting in strong oscillations. At 21:45, half of the passengers were in the restaurant as the second dinner service was served. The remaining passengers are spread between passenger areas and participating in events, such as shows in the theatre. At this point, the cruise ship is in full swing with crew members and personnel busy. No announcements were made in the first few minutes after the impact and, therefore, the passengers, without indications on how to behave, relied on their own instinct. Some reached the muster stations while others went to their cabins to collect their personal belongings and collect a life jacket. Many stopped in the corridors or halls, persistently asking crewmembers for information who, at the time, were unaware of the nature and severity of the problem. At 21:54 the first announcement was issued which recommended everybody ‘to keep calm’. The only report was a fault with the ship's generators.

The situation, however, was already present in all its gravity. This was enough to induce some passengers to suspect that the situation was so serious that it could not be communicated. Only at 22:33 was the general emergency signal given. This consisted of seven long whistles and a single short one. However, this was not followed by the expected announcements informing the passengers. Instead, they were invited to reach deck four, where the muster stations for boarding the lifeboats were located. The emergency boats were not launched immediately as the ‘abandon ship’ order was seriously delayed, only taking place at 22:54. This delay complicated the timely and regular development of evacuation operations. During this time, the ship had reached an inclination causing serious difficulties in lowering the lifeboats. Ultimately, while the passengers on the starboard side managed to get on the lifeboats and reach the Island of Giglio or the nearby rocks, those who were on the port side of the Concordia remained stranded on deck four, unable to lower lifeboats. Following the impact, the ship ran aground, pushed by the currents, on the starboard side at Punta Gabbianara.

Table 1. Timeline of events of the Costa Concordia accident

Time	January 13th, 2012
21:45	The ship impacted an underwater rock of "Le Scole", the impact causes a 50-meter gash in the hull and immediately caused the main engines to malfunction and lose power
21:50	The ship experiences a blackout on board. Emergency generators malfunction as they fail to connect with the electrical panel, supplementary batteries guarantee enough energy for emergency lighting and communication systems.
21:54	Technical generator problems are announced to passengers through public address system.
21:55	Compartments 6 and 7 (generator rooms) and compartment 5 (engine room) are reported as flooded.
22:11	Compartment four is also reported to be flooding.
22:15	Passengers are instructed to remain calm and either return to common areas or return to their cabins.
22:25	The captain reports to port authority that the ship was taking on water on the left side and had started heeling. The captaincy asks if assistance is needed and from the bridge, they ask for assistance from a tugboat.
22:30	Some passengers start boarding lifeboats autonomously, even though no general emergency or abandon ship announcements were given.
22:33	The general emergency signal is raised through the blowing of seven short whistles and one final long blast. No worded announcements are made to passengers.
22:36	A 'distress' call is communicated to the port authority due to the ship's increasing listing.
	Public announcements to collect lifejackets and assemble at muster stations are given to passengers.
22:39	The rescue patrol boat G 104 arrives in proximity of the Concordia and communicates it to be down-by-the-stern.
22:40	The Costa Concordia contacts port authority and urges request for tugboat assistance.
22:44	Patrol boat G 104 reports that the vessel is laying on the bottom starboard

Time	January 13th, 2012
	side.
22:45	The captain denies that the unit is resting on the bottom, declares that the ship is floating and at the request for navigation capacity a positive response is given with intention to continue to get closer to the coast.
22:48	Port authority asks if they have evaluated the possibility of giving the ship abandonment order, they reply that they are considering the decision.
22:54	The order to abandon ship is announced; lifeboats are lowered and start launching.
23:10	Patrol boat G 104 reports that motored lifeboats have been launched and have begun sailing towards the Island of Giglio while the non-motor ones will be recovered and transhipped on board the Aegium ferry.
23:20	The Costa Concordia Captain gave the order to abandon the bridge of command, after inspecting some bridges, abandoned the ship aboard one of the last available lifeboats.
23:38	An estimated number of 300/400 people still on board are reported.
23:40	Patrol G 104 reports that the ship's heeling was dramatically increasing.
Time	**January 14th, 2012**
00:00	The vessel further accentuates the heeling on the starboard side, making it impossible to board the lifeboats and thus forcing people to remain on board the ship.
00:18	Patrol GF 104 reports that the ship is about to capsize.
00:21	Passengers and crew are reported to have jumped overboard on the starboard side.
00:36	Patrol G104 and Coastal Guard helicopter report the presence of passengers (including children) still on board, estimating about 70 – 80 people.
00:41	The ship is reported to have listed to 90° with an estimate of 40 – 50 people stranded on board.
00:53	Rescue operations by helicopter begin.
01:04	Rescuers lowered onto the ship report that from his location there are still about 100 people on board.
03:05	Patrol GF 104 reports that on board they have 5 injured and 3 deceased
04:22	Patrol GF announces that, from a visual estimate, about 30 people remain on board.
04:46	Patrol GF reports that only fire fighters and rescue operators are visibly on board, inspections continue.
05:14	Deck Officer Pellegrini returns on board with fire fighters to check for the presence of passengers still on board.
06:17	Fire fighters and Officer Pellegrini disembark because of difficult research conditions.

Rescuers suspended surface search on the 25^{th} of January 2012 and continued underwater searches until the body of the last missing person was found and identified in November 2014 (ANSA, 2014).

Chapter Four: An Assessment of Maritime Evacuation Research Methods

4.1. Roadmap of Investigation

The scarcity of reliable real-life data is problematic for the progress of research in the field of maritime evacuation. There exists a severe lag in comparison to the level of modelling available in fire evacuation scenarios. However, comparison with other methods and models only tests the similarity between them, not the accuracy with which they represent a real event (Kuligowski et al., 2017). It must be noted that accounts provided by real-life participants are not necessarily accurate portrayals of events (Wood, 1980). These accounts are further distorted through cognitive processes affecting memory and the trauma associated with remembering. Thus, it is necessary to assess potential methods for extracting data of higher quality and in greater volumes. Furthermore, it is equally necessary to pinpoint the precise nature of such data and the logical mechanics underpinning any analysis performed in order to ascribe clear meaning to results.

To make this assessment, this thesis comprises three interconnected studies. Each study is based on behavioural sequence analysis (Canter et al., 1980; Keatley, 2019). This is currently the most appropriate form of data analysis with respect to examining sequences of acts. However, a current limitation is that this method provides little insight into motivations. The first study exists as a replication of a previous study which used this method to detect similarities between fire evacuations and maritime evacuations (Canter & Finiti, 2015). The data was obtained from a different sample of the same population of survivors of the Costa Concordia disaster. Further examination of potential intra-cohort differences will be undertaken. This will be performed by breaking down the cohort into categories based on gender, age, companions, and experience.

The second study is a recreation of the first study using the talk-through method. Data will be collected from accounts provided by participants imagining how they would act in a situation similar to that of the Costa Concordia disaster. The third study will be a thorough comparison of the findings of the first two studies. Dependent on these findings, recommendations will be made for possible ways to bridge the current gap between maritime and fire evacuation modelling.

4.2 Study 1: Assessing the Reliability of Behavioural Sequence Analysis

4.2.1 Introduction

Data available for research into maritime disasters is scarce. Thus, what little data exists requires thorough examination through effective and informative methods. The aim of this study is a replication of the Canter and Finiti (2015) study with new data obtained from previously unexamined transcripts. These data will then be compared with the data extracted in the previous study. Previously, it was necessary to make comparisons between Costa Concordia data and building fire data (Canter et al., 1980). This revealed general similarities, which were then used to create a general taxonomy of actions. However, as has been stated, the environment and evolution of a disaster is fundamental to decision-making during evacuation. Therefore, for corroborative purposes, it is more meaningful to compare data from different cohorts within the same evacuation scenario. It is predicted that preliminary comparative analysis will show significant similarities between the actions of each cohort as a whole.

If such significant whole-cohort similarities are found, this will be considered corroborative evidence for a generalized model of human decision-making in evacuation scenarios. It will also be considered evidence for the reliability of the behavioural sequence analysis method. All further analysis will then be undertaken only on the data collected in the present study. This will consist of an examination of the actions of categories of individuals within each cohort. The categories under investigation are age, gender, companions, and experience. It is anticipated that certain differences will become apparent.

4.2.2 Data Sources

Transcripts of fifty-three survivors' witness statements from the Italian court proceedings concerning the Costa Concordia penal trial were obtained. The sample consisted of 53 persons of Italian nationality. There were 24 adult males (M=48, SD=15.23) and 29 adult females (M=48, SD=13.71), aged between 29 and 79 (M=48, SD=14.28). In the transcripts, survivors recounted their experience on the Costa Concordia cruise ship on the night of the accident, 13th January 2012.

4.2.3 Analysis and Results

Survivors' accounts were analysed individually and arranged and presented as a sequence of acts. The descriptions within the accounts were coded in order to produce a taxonomy of acts similar to that produced in Canter and Finiti (2015) (see Table 2). The codes were subsequently reviewed by an independent researcher for purposes of consistency.

Table 2. Taxonomy of acts

Code	Description	Frequency
1	Pre-event Activity	53
2	Hear strange noises	19
3	Feel Vibrations	21
4	Blackout	26
5	Feel Ship Heeling	27
6	Encounter water	10
7	Feel Impact	30
8	Engine Problems	6
9	Open Water Phenomenon	7
10	Look for Crewmembers	13
11	Note behaviour of others	26
12	Search for travel companions	19
13	Reassure Others	2
14	Remain in position/Wait for Instructions	15
15	Instructed to go to cabin/halls	31
16	Instructed to gather at Muster Station	19
17	Receive Contrasting Instructions	8
18	Experience Negative Feelings	15
19	Experience Uncertainty and Extreme Fear	29
20	Frustration/Anger towards Crew	11
21	Follow Instructions	24
22	Encounter problem following instructions	8
23	Disregard Instructions	20
24	Act Autonomously	17

Code	Description	Frequency
25	Search for Life Vests	40
26	Go to Muster Station	47
27	Demand to board Lifeboats	7
28	Search for Lifeboat amid chaos on board	42
29	Force way onto Lifeboat	20
30	Disembark Stuck Lifeboat	14
31	Abandon Ship - End of Involvement	53

These acts were then combined into more general categories of acts (see Table 3). The frequency of each generalised act was then noted. It was decided to retain accounts of emotional involvement, as a 'non-act', as a potentially interactive variable.

The 'present' and 'previous' taxonomies were then compared (see Table 4). As can be seen, the categories do not map perfectly. This is a result of objective coding; no attempt was made to crowbar statements into the previously used general taxonomy. The unique categories of 'Follow others' and 'Search for family members' in the present study seem to have replaced 'Stay in position' from the previous study. This may reflect a different demographic between samples, or a difference in nuance of description, but all would fall into the 'Act' level of the general model. However, initially, for the purposes of the current statistical comparison, these categories will be omitted. Similarly, the 'Experience Negative Emotions' category was omitted due to no comparison available and its 'non-act' status. Conversely, minor differences in the categories of 'Receiving Instructions' and 'Following Instructions' were considered equal.

Table 3. Generalised taxonomy of acts and the frequency with which they were reported

Original Taxonomy			General Taxonomy		
Code	Description	Frequency	Code	Description	Frequency
1	Pre-event Activity	53	a	Pre-event Activity	53
2	Hear strange noises	19	b	Ambiguous Perception	66
3	Feel Vibrations	21			
4	Blackout	26			
5	Feel Ship Heeling	27	c	Unambiguous Perception	67
6	Encounter water	10			
7	Feel Impact	30			
8	Engine Problems	6	d	Incorrect Interpretation	13
9	Open Water Phenomenon	7			
11	Note behaviour of others	26	e	Follow others	26
12	Search for travel companions	19	f	Search for travel companions	19
10	Look for Crewmembers	13	g	Seek information	30
13	Reassure Others	2			
14	Remain in position/Wait for Instructions	15			

Original Taxonomy			General Taxonomy		
Code	Description	Frequency	Code	Description	Frequency
15	Instructed to go to cabin/halls	31	h	Receive Instructions	58
16	Instructed to gather at Muster Station	19			
17	Receive Contrasting Instructions	8			
18	Experience Negative Feelings	15	i	Experience Negative Feelings	55
19	Experience Uncertainty and Extreme Fear	29			
20	Frustration/Anger towards Crew	11			
21	Follow Instructions	24	j	Follow Instructions	32
22	Encounter problem following instructions	8			
23	Disregard Instructions	20	k	Act Autonomously	37
24	Act Autonomously	17			
25	Search for Life Vests	40	l	Seek further assistance	94
26	Go to Muster Station	47			
27	Demand to board Lifeboats	7			
28	Search for Lifeboat amid chaos on board	42	m	Initiate evacuation process – Board lifeboats	62
29	Force way onto Lifeboat	20			
30	Disembark Stuck Lifeboat	14	n	Encounter evacuation problems	14

Original Taxonomy			General Taxonomy		
Code	Description	Frequency	Code	Description	Frequency
31	Abandon Ship - End of Involvement	53	o	Abandon Ship - End of Involvement	53

The more detailed categories of the previous study were collapsed into single categories for the purpose of the current comparison. This resulted in 12 categories of the taxonomy of the present study being considered comparable to 14, collapsed to 12, of the Canter and Finiti (2015) study (see Table 4). Consequently, the frequencies were compared, and a correlation analysis was undertaken.

Table 4. Categorized frequency comparison v Canter and Finiti (2015)

Present Study		Canter and Finiti (2015)	
Categorization	n^a	Categorisation	n^b
Pre-Event Activity	53	Pre-event action	30
Ambiguous Perception	66	Ambiguous perception	50
Unambiguous Perception	67	Unambiguous perception	38
Incorrect Interpretation	13	Incorrect interpretation	5
Seek information	30	Seek information	32
Follow others*	26	Stay in position*	11
Search for travel companions*	19		
Receive instructions	58	Receive contrasting instruction#	4
		Receive unambiguous instructions#	33
Experience negative feelings*	55		
Follow instructions	32	Follow instructions#	16

Present Study		Canter and Finiti (2015)	
Categorization	n^a	Categorisation	n^b
		Problems following instructions#	4
Act autonomously	37	Act autonomously	21
Seek further assistance	94	Seek further guidance	51
Initiate evacuation process	62	Effect departure	31
End of Involvement	53	End of involvement	30

n^a = sum of frequencies of reported action in the present study.

n^b = sum of frequencies of reported actions in Canter and Finiti (2015)

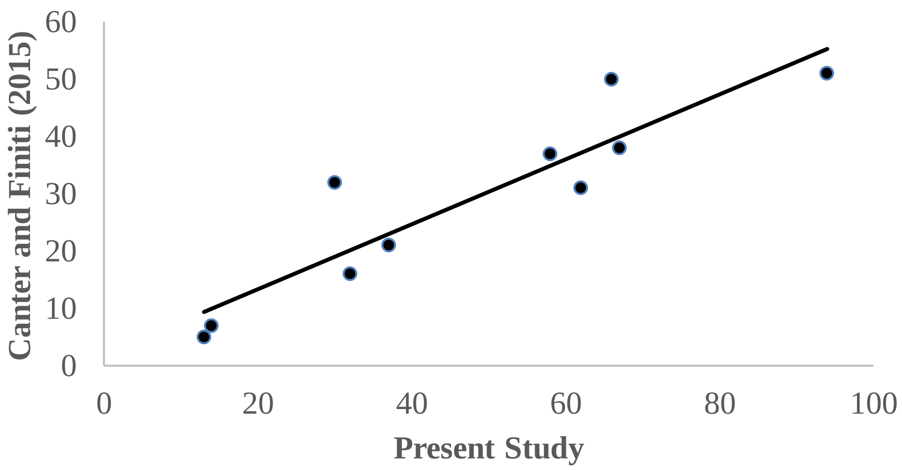
* = omitted from current analysis

= combined into a single category

Initial data cleansing consisted of deciding to omit the categories ‘Pre-Event Activity’ and ‘End of Involvement’. These counts essentially make a note of the beginning and end of each participant’s account. They are perfectly correlated and were considered to be uninformative and a potentially undue influence on the statistical analysis for the present purposes. A Shapiro Wilk test showed the frequency of acts in each study to be normally distributed (Present Study: $W(10) = 0.939$, $p = .513$; Previous Study: $W(10) = 0.940$, $p = .525$). A Pearson correlation was undertaken which showed a significant correlation between the frequencies with which similar experiences were reported in each real-life scenario ($r(8) = .91$, $p < .001$) (see Figure 5).

Due to the high correlation, it was decided to revisit the omission of non-comparable account categories. The original omission of these categories, ‘Stay in Position’ from the previous study, and ‘Follow Others’ and ‘Search for Travel Companions’ in the present study, was decided upon due to there being no perfect comparison. However, for the purposes of complete comparison, it was decided to enter each frequency versus a null counterpart. The accounts of emotions were still omitted as they constitute ‘non-actions’.

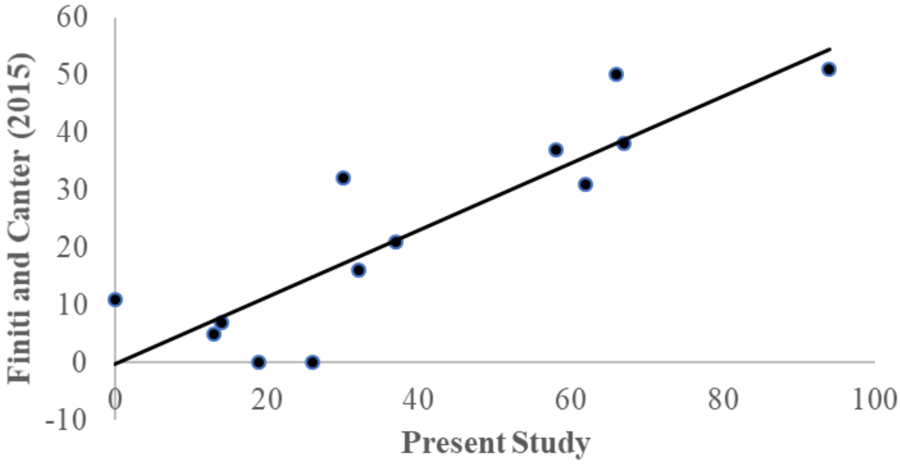
Figure 5. Scatterplot of comparison of frequencies of similarly reported actions between the present study and Canter and Finiti (2015)



A Shapiro Wilk test showed the frequency of acts in each study to be normally distributed (Present Study: $W(13) = 0.949$, $p = .549$; Previous Study: $W(13) = 0.924$, $p = .353$).

When re-introducing the three omitted action categories, a Pearson correlation still showed significant similarity ($r(11) = .88$, $p < .001$). This was taken as evidence for the granularity and general trajectory of the accounts of each cohort being similar, notwithstanding certain differences in content (see Figure 6).

Figure 6. Scatterplot of comparison of frequencies of all reported actions between the present study and Canter and Finiti (2015)



The significant correlations found were considered strong evidence for the data collection and coding undertaken in the present study to be sound. Even when perfect mapping of generalized categories did not exist, the similarity in frequency of report of other actions was strong enough to overcome null comparisons.

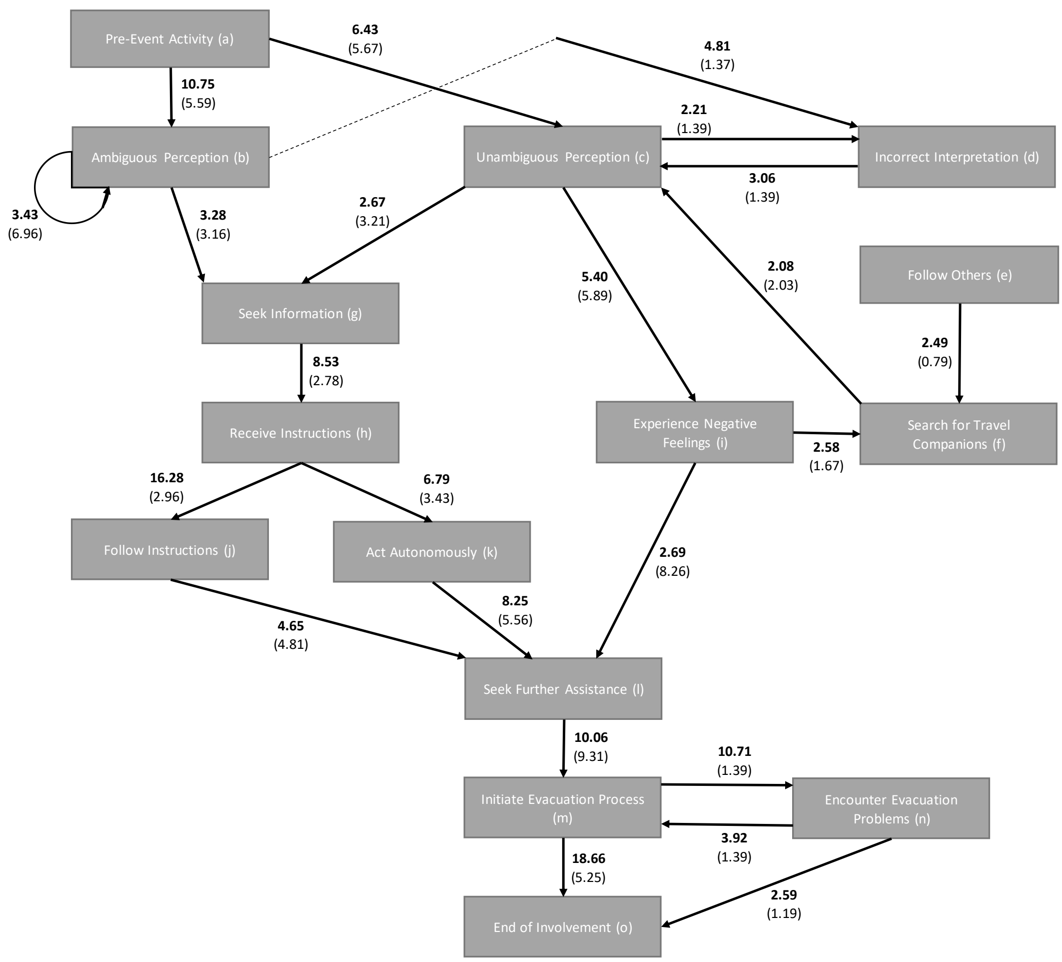
4.2.4 Behavioural Sequence Analysis

Behavioural sequence analysis is a method of investigating human behaviour. It involves utilizing qualitative data within a quantitative method in order to allow for a thorough understanding of behaviour. It has been noted that "sequential analysis is a visual, quantitative approach to data that allows a researcher to achieve a richer qualitative understanding by 'looking at the data to see what it seems to say'" (Fossi et al., 2005, p.1447). By categorizing behaviours and analysing the transitions and sequential patterns, sequence analysis allows for an in-depth comprehension of such behaviour. Through sequential analysis a researcher is able to identify multiple variables within a system, observe and describe their function, connection, and contribution to the system overall (Keatley, 2019). It is through the analysis of statistical relationships between behaviours that a sequential pattern of behaviour can be produced, and a particular event investigated thoroughly (Bakeman & Quera, 2011). Clarke and Crossland (1985) assert that behavioural sequence analysis requires three stages: coding behaviours into discrete events, arranging by similarity the events into groups, and finally establishing, using transitional matrices, the frequency of transitions between events. Through this analysis it is possible to identify sequential patterns, meaning transitions occurring above the expected level of chance. Ultimately, in order to visually portray the sequential patterns of behaviour, a decomposition or state transition diagram is then produced.

The first stage of analysis focused on the comparison of the frequency of each category of actions reported by different cohorts in the same scenario. The significant correlations found indicate high similarity between the accounts of survivors. In turn, this indicates similarities in the detail of descriptions provided by survivors and an idea of the number of types of decisions to be made in evacuation scenarios. To investigate the sequence of acts or whether certain acts are initiated in response to other acts with any reliable strength of association, behavioural sequence analysis was undertaken.

As seen in Table 3, the generalized taxonomy of acts consisted of 15 categories coded ‘a’ to ‘o’. A preliminary table was constructed of the coded route from ‘Pre-Event Activity’ to ‘End of Involvement’ for each participant. This list of actions was then transformed into a matrix showing the frequency with which each action was followed by a certain subsequent action. For consistency, the method used in Canter et al. (1980) to determine ‘strength of association’ was used. This calculation involves ‘observed frequency’ minus ‘expected frequency’ divided by the square root of the ‘expected frequency’. The expected frequency of a transition is calculated as the multiple of the total number of observations of each act in the transition, divided by the grand total of acts observed. This ‘base rate’ guards against acts which were observed many times seeming to show high strengths of association based merely on their prevalence. A strength of association greater than ‘2’ was considered noteworthy. However, the associated base rates must be taken into account during analysis. The resultant strengths of association between acts are shown in bold, with base rates in brackets, which were then used to construct a decomposition diagram (see Figure 7).

Figure 7. Decomposition diagram showing strength of association (and base rate) between actions during the evacuation of the Costa Concordia



Due to the visual nature of decomposition diagrams and the concentration of data they portray, coupled with the prevalence of such diagrams later in this thesis, it was decided to adopt a standard method for interpretation. Firstly, a route from 'Pre-Event Activity' would be established based on the greatest strength of association until either 'End of Involvement' or an act was repeated. Secondly, a note would be made of the three individual transitions which showed the greatest strength of association to base rate ratio. The first of these is intended to act as a practical guide to the actions taken during an evacuation. The second of these is intended to act as a signifier of the importance of such actions within the evacuation process. This second part of the interpretation may also be used to more clearly highlight potential differences in action sequences later in this thesis.

The standardised route described in this decomposition diagram is a-b-d-c-i-l-m-o. This route is perhaps interesting as it avoids the 'instructive' phase of the diagram signified by acts h, j, and k. Instead, the reports of emotions divert this route. The three transitions with greatest strength of association to base rate ratios are 'Initiate Evacuation Process' to 'Encounter Evacuation Problems' (mn, R = 7.71), 'Receive Instructions' to 'Follow Instructions' (hj, R = 5.50), and 'Initiate Evacuation Process' to 'End of Involvement' (mo, R = 3.55). Again, it is interesting to note that the route of acts implied by the strengths of association do not include the top two transitions.

The decomposition diagram gives a portrait of a seemingly logical route taken during an evacuation. This would suggest good face validity. If a route is plotted following the greatest strengths of association, one would move from "Pre-Event Activity' to 'Ambiguous Perception' to 'Incorrect Interpretation' before attaining 'Unambiguous Perception'. Each transition in this sequence demonstrates a strength of association at least approximately double the base rate. Once "Unambiguous Perception' is attained, the strengths of association weaken to around the base rates. It is at this point that the reports of negative feelings are greatest. This is then linked to the social acts of following others and seeking travel companions, which then loops back to, perhaps, a collective unambiguous perception. Once information has been sought and instructions received, there seems to be a high tendency to follow these instructions. Those who reported themselves to have acted autonomously then show a strong association with seeking further assistance. It is once this further assistance is acquired that evacuation is initiated and completed. Interestingly, it is during this part of evacuation that the greatest strength of association to base rate ratio can be seen between initiating evacuation and encountering problems. This may be an artefact of the manner in which the account was taken. Those who did encounter problems would appear to be in a small minority from the base rate. However, it would be a notable part of the evacuation for those who encountered such problems. Conversely, those who did not encounter problems would not report absence of such an act.

4.3 Trait Analysis

Four traits were recorded for each participant. These were gender, age, companions, and previous experience. The coded accounts of the entire cohort were split into the appropriate categories and examined for potential differences. The 'expected frequency' of all calculations was the pro-rated expected frequency of the entire cohort. This was used to highlight differences in both strength of association and number of times transitions were reported. The cut-off point of '2' was used throughout as qualifying as a strength of association.

4.3.1 Gender

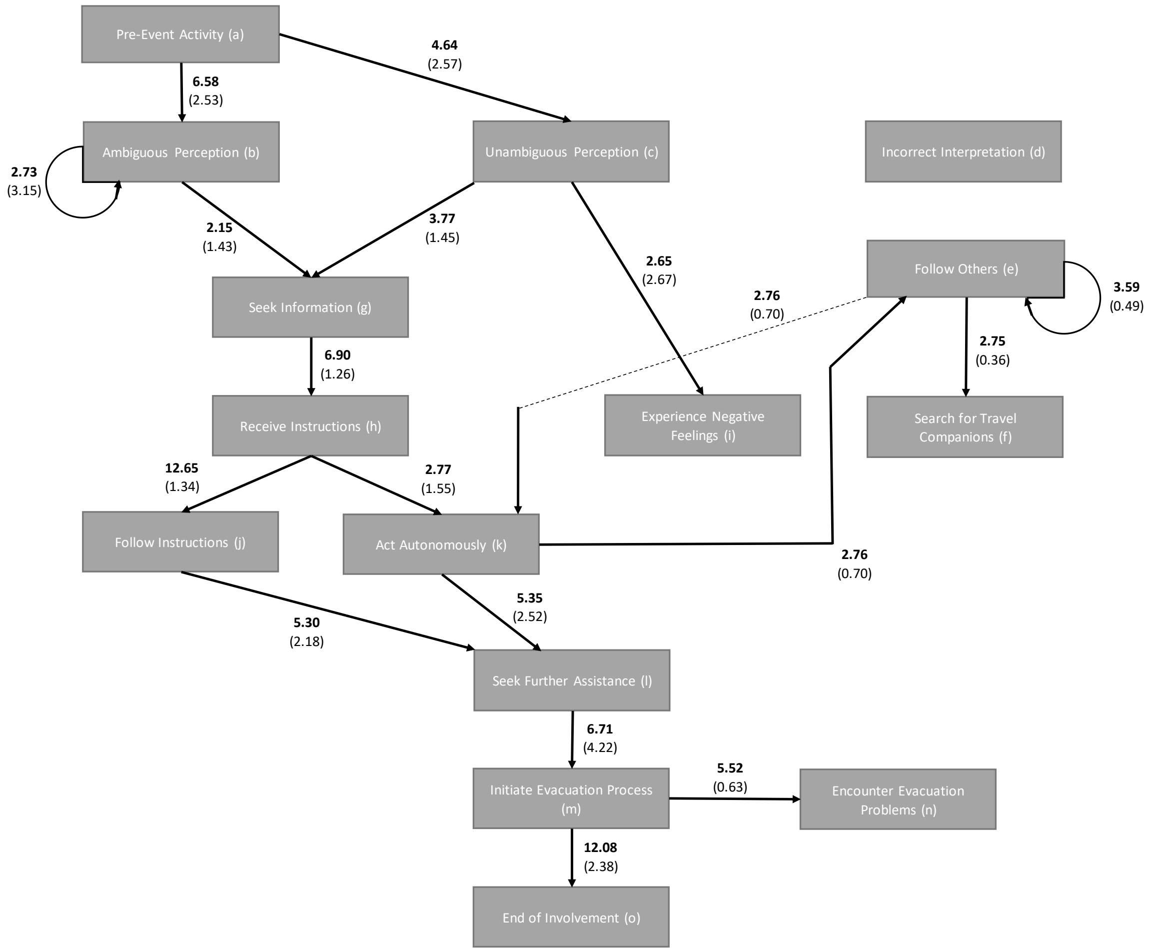
The complete cohort of 53 participants consisted of 24 males and 29 females. Initially, the frequencies of acts of each sub-cohort were recorded (see Table 5).

Table 5. Frequency comparison between male and female passengers

Act	Male	Female
Pre-Event Activity	24	29
Ambiguous Perception	29	37
Unambiguous Perception	32	35
Incorrect Interpretation	3	10
Follow others	15	11
Search for travel companions	6	13
Seek for information – Investigate	17	13
Receive Instructions	27	31
Experience Negative Feelings	22	33
Follow Instructions	17	15
Disregard Instructions – Act Autonomously	18	19
Seek further assistance	43	51
Initiate evacuation process – Board lifeboats	26	36
Encounter evacuation problems	5	9
End of Involvement – Abandon Ship	24	29

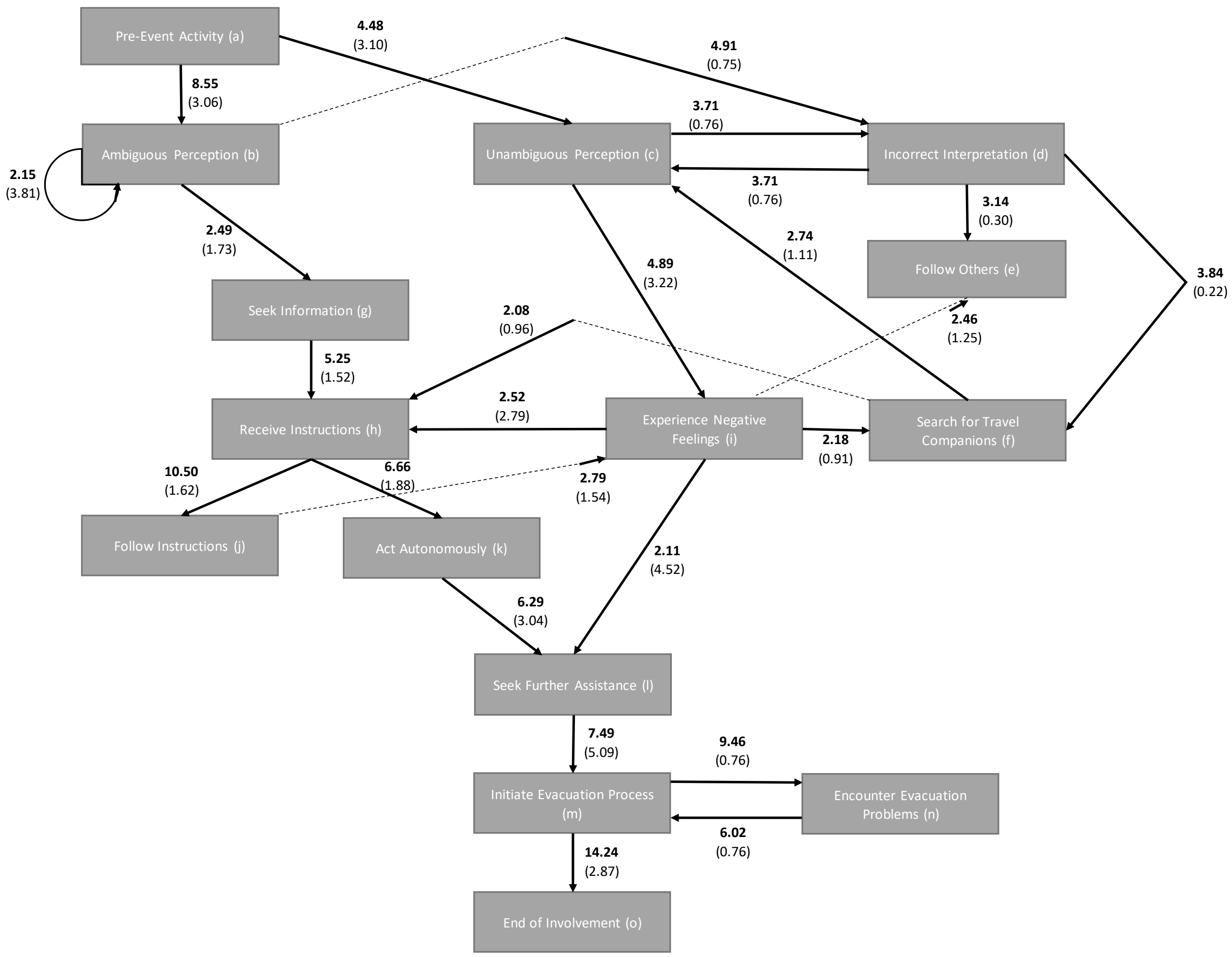
A Shapiro Wilk test showed the frequency of acts for each sub-cohort to be normally distributed (Males: $W(13) = 0.964$, $p = .808$; Females: $W(13) = 0.881$, $p = .074$). The result of this test shows that the data distribution for females could be considered borderline, however analysis continued with a cautionary note. A Pearson correlation was undertaken which showed a significant correlation between the frequencies with which similar experiences were reported by males and females ($r(11) = .93$, $p < .001$). Decomposition diagrams were then constructed for the male and female categories of the cohort (see Figures 8 and 9).

Figure 8. Decomposition diagram showing strength of association between actions taken by males during the evacuation of the Costa Concordia



The standardised route, meaning a route going from ‘Pre-Event Activity’ based on the greatest strength of association until either ‘End of Involvement’ or an act, depicted in this decomposition diagram (Figure 8) for the male sub cohort is a-b-b. This route is brought to an abrupt end due to the repetition of reports of ‘Ambiguous Perception’. The three transitions with greatest strength of association to base rate ratios are ‘Receive Instructions’ to ‘Follow Instructions’ (hj, R = 9.44), ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (mn, R = 8.76), and ‘Follow Others’ to ‘Search for Travel Companions’ (ef, R = 7.64).

Figure 9. Decomposition diagram showing strength of association between actions taken by females during the evacuation of the Costa Concordia



The standardised route described in the decomposition diagram (Figure 9) of the actions taken by females is a-b-d-f-c-i-h-j-i. This route is brought to an end due to the repetition of reports of ‘Experience Negative Feelings’. The three transitions with greatest strength of association to base rate ratios are ‘Incorrect Interpretation’ to ‘Search for Travel Companions (df, R = 17.45), ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (mn, R = 12.45), and ‘Incorrect Interpretation’ to ‘Follow Others’ (de, R = 7.64).

A comparison of these diagrams would suggest females report having taken many more different types of actions before the ‘Unambiguous Perception’ stage. Males seem not to report incorrect interpretations. Once unambiguous perception is attained, females have a high strength of association with reporting negative feelings. Males, however, show a greater strength of association for information-seeking actions rather than reporting feelings. Males seem to receive instructions before initiating social acts such as seeking companions. They also seem more likely to report having followed others. Once instructions are received, males report following them while females seem more split with acting autonomously. This coincides with more incidents of reporting negative feelings. Females also appear more likely to report problems during evacuation.

In summary, the two methods of analysis outlined as standardised highlight differences between both the acts and transitions reported by males versus females. The routes through evacuation implied by the strengths of association are starkly different. That of the males begins to loop immediately with repeated reports of ‘Ambiguous Perception’. As noted, males seem more prepared to report ‘Ambiguous Perceptions’ rather than their own ‘Incorrect Interpretations’. The route of the females begins a more extended loop centred around the ‘Report Negative Feelings’ node. This would seem to reflect a greater propensity for females to report this act. With respect to the strength of association to base rate ratios, both sub-cohorts show ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (transition ‘mn’) as the second most important transition. As previously stated, this particular transition is expected to be one that is highly reported. If there were an issue with evacuation, it is a natural progression in story telling for those affected to report such a problem. Females again demonstrated the inclination to report ‘Incorrect Interpretations’ with the first (to ‘Search for Travel Companions’) and third (to ‘Follow Others’) important transitions involving this act. Males, on the other hand, showed the greatest propensity for following instructions (transition ‘hj’). The third highest transition ratio involved those acts most reported by females following ‘Incorrect Interpretation’. Males, however, transitioned to ‘Search for Travel Companions’ directly from ‘Follow Others’ (transition ‘ef’).

It is also of interest to compare the decomposition diagrams of males and females to that of the entire cohort (see Figure 7). It is important to remember that the ‘expected values’ for the transitions of each sub-cohort were based on a pro-rated value of the expected values of the entire cohort. This was used to highlight differences in both strength of association and number of times transitions were reported. With respect to the route of evacuation implied by the strengths of association, neither sub-cohort provides a complete route from beginning to end of involvement as is provided by that of the complete cohort. However, certain parallels and reflections are apparent. As noted, the standardised route apparent in the entire cohort avoids the instructive phase, instead moving via ‘Experience Negative Feelings’. This act is the one at which female accounts began to loop. Alternatively, the second most important transition noted in the entire cohort was that which was most important in the male sub-cohort: following instructions (transition ‘hj’). These sub-cohort findings would seem to account for the somewhat unexpected results in the entire cohort. However, perhaps of greatest interest is that the transition with the greatest strength of association to base rate ratio in the entire cohort is that which also appears in the top three transitions of each sub-cohort: ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (transition ‘mn’). Although transitions were calculated to highlight differences from the ‘complete cohort’ norm, each sub-cohort demonstrates the importance of this transition. Furthermore, it has already been noted that the importance of this particular transition is expected as a result of natural storytelling. If there were no problems encountered during the evacuation, they would not be reported. However, if problems were reported, it would be natural for them to be reported once the initiation of the evacuation process had been reported. This would suggest that the way in which an individual chooses to tell a story is of vital importance to the results acquired through behavioural sequence analysis.

4.3.2 Age

The complete cohort of 53 participants consisted of 21 participants under the age of 41 years old, 20 between the ages of 41 and 60, and 12 aged over 60 years. The frequencies of acts of each sub-cohort were recorded (see Table 6).

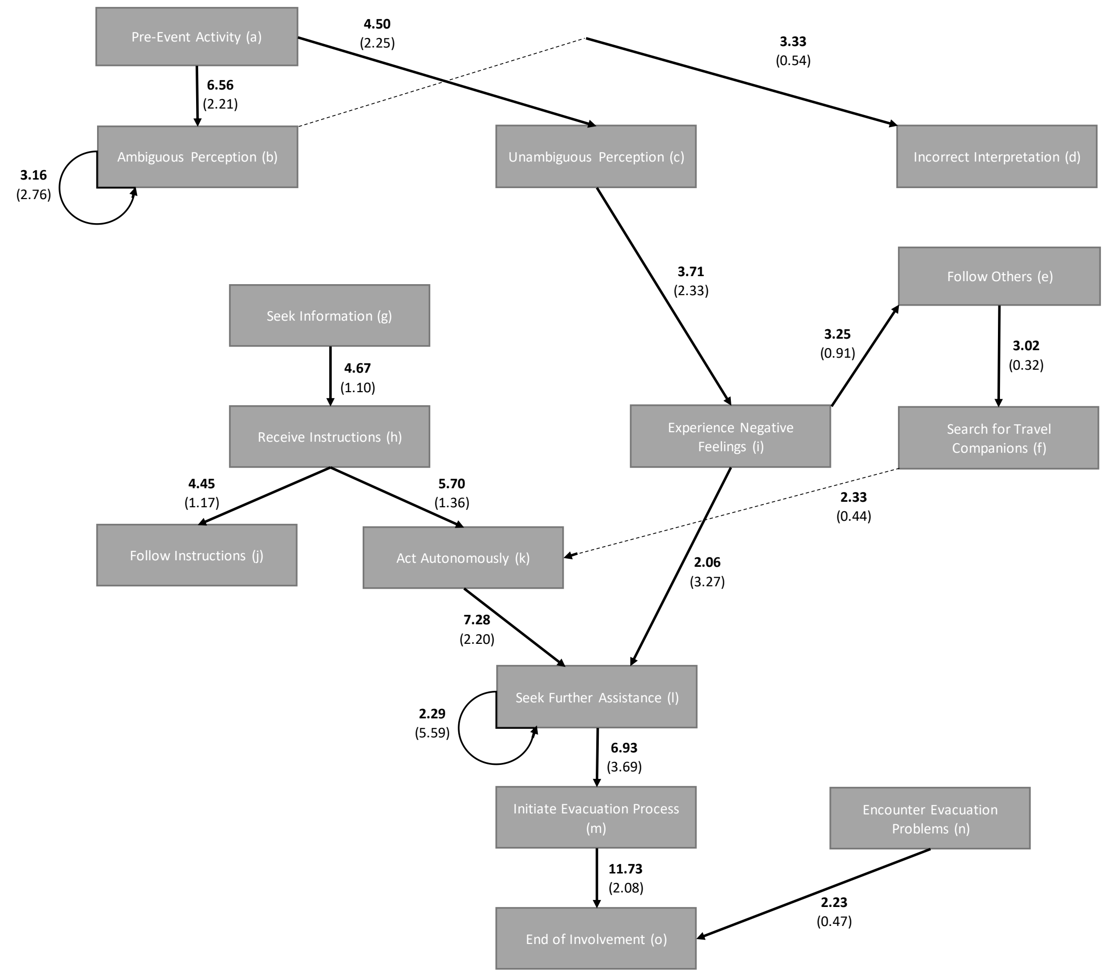
Table 6. Act frequency comparison between passenger by age group

Act	< 41	41 - 60	> 60
Pre-Event Activity	21	20	12
Ambiguous Perception	26	29	11
Unambiguous Perception	27	20	20
Incorrect Interpretation	4	7	2
Follow others	11	9	6
Search for travel companions	6	8	5
Seek for information – Investigate	9	14	7
Receive Instructions	21	23	14
Experience Negative Feelings	23	17	15

Act	< 41	41 - 60	> 60
Follow Instructions	6	15	11
Disregard Instructions – Act Autonomously	19	13	5
Seek further assistance	41	32	21
Initiate evacuation process – Board lifeboats	21	25	16
Encounter evacuation problems	2	6	6
End of Involvement – Abandon Ship	21	20	12

A Shapiro Wilk test showed the frequency of acts for each sub-cohort to be normally distributed (<41: $W(13) = 0.930$, $p = .343$; 41 - 60: $W(13) = 0.942$, $p = .486$; >60: $W(13) = 0.932$, $p = .365$). Pearson correlation analysis was undertaken which showed significant correlations between the frequencies with which similar experiences were reported by each age group ('<41 v 41-60': $r(11) = .88$, $p < .001$; '<41 v >60': $r(11) = .83$, $p < .001$; 41-60 v >60: $r(11) = .81$, $p < .001$). Decomposition diagrams were then constructed for each sub-cohort (see Figures 10, 11, 12).

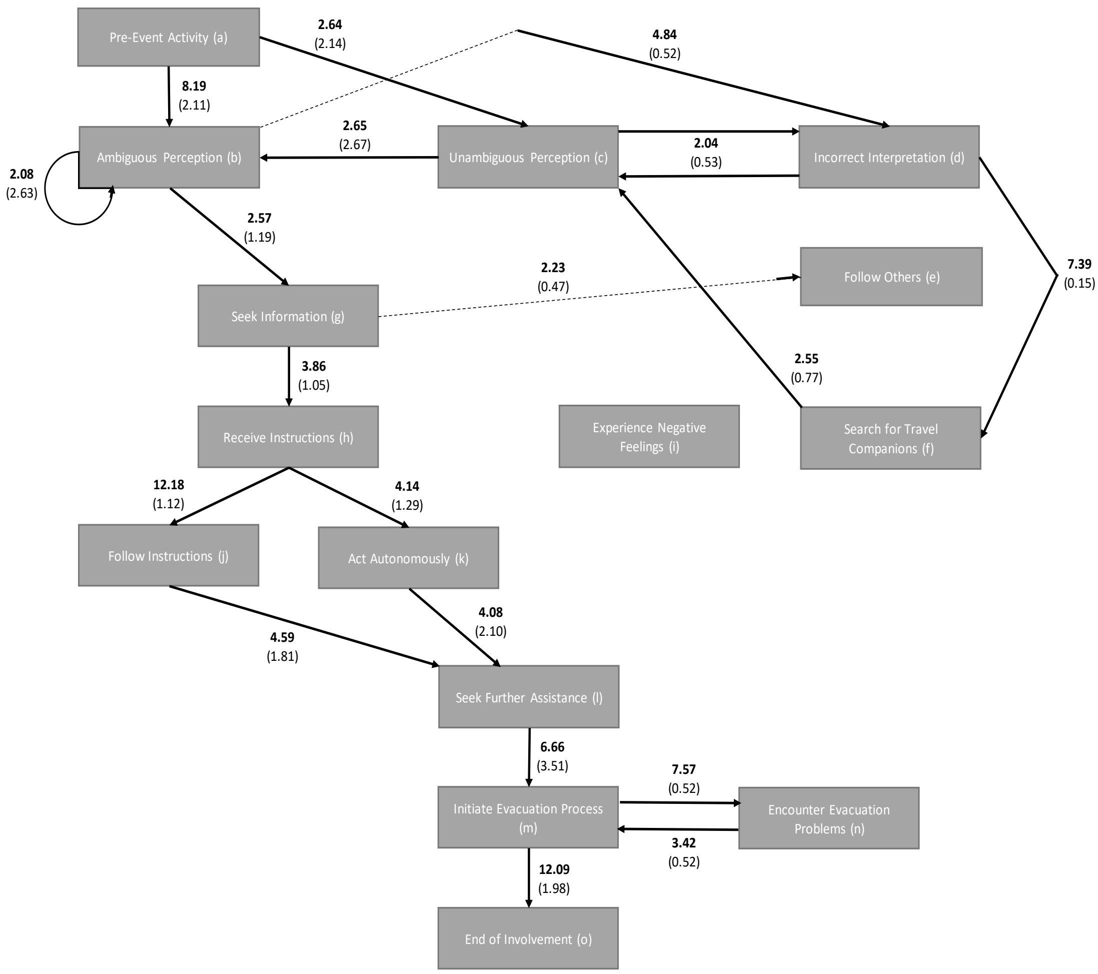
Figure 10. Decomposition diagram showing strength of association between actions taken by participants under the age of 41 during the evacuation of the Costa Concordia



The standardised route, meaning a route going from 'Pre-Event Activity' based on the greatest strength of association until either 'End of Involvement' or an act, described in the decomposition diagram depicting the actions taken by participants under the age of 41 is a-b-d. This route is brought to an end due there being no transition with sufficient strength of association following the act 'Incorrect Interpretation'. The three transitions with greatest strength of association to base rate ratios are 'Follow Others' to 'Search for Travel

Companions' (ef, R = 9.44), 'Ambiguous Perception' to 'Incorrect Interpretation' (bd, R = 6.17), and 'Initiate Evacuation Process' to 'End of Involvement' (mo, R = 5.64).

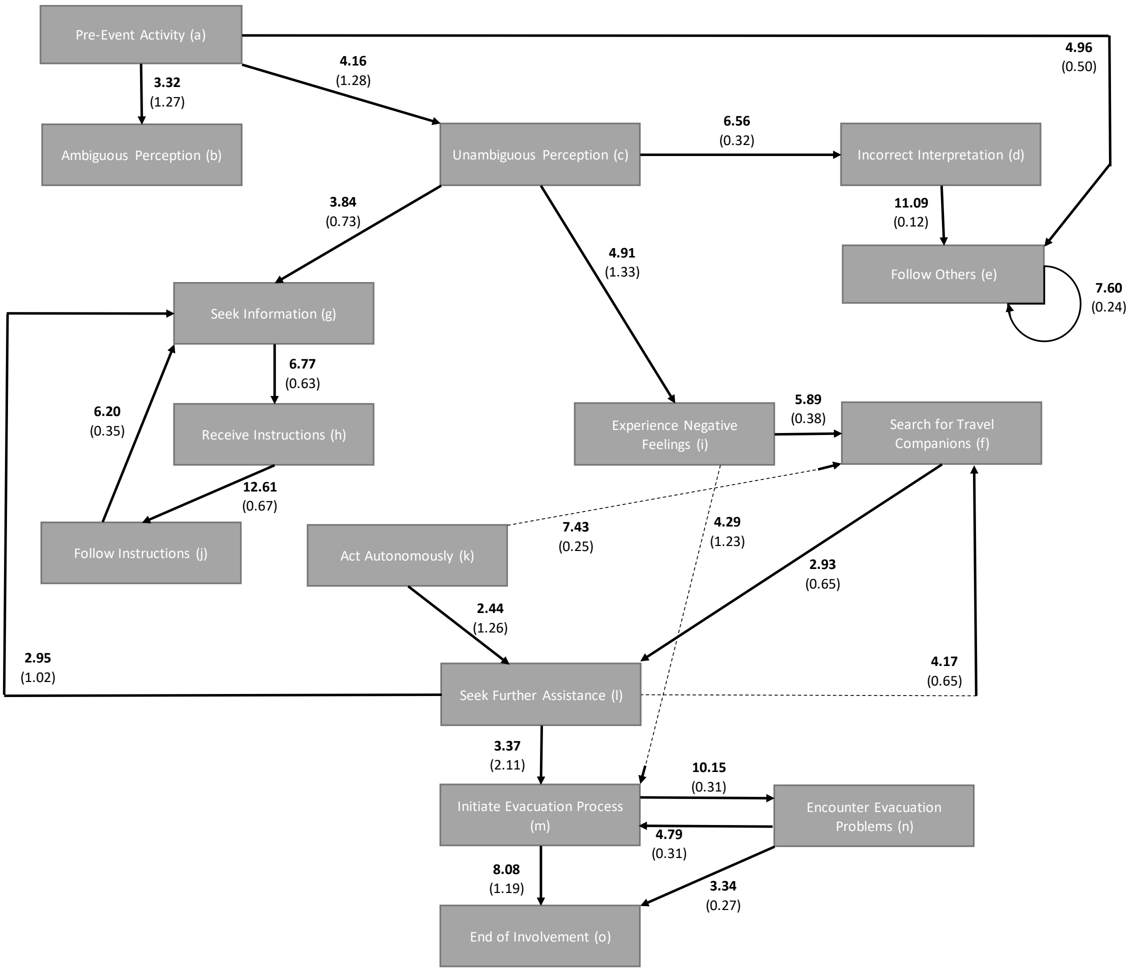
Figure 11. Decomposition diagram showing strength of association between actions taken by participants between the ages of 41 and 60 during the evacuation of the Costa Concordia



The standardised route described in the decomposition diagram depicting actions taken by participants aged between 41 and 60 is a-b-d-f-c-b. This route is ended by looping back to 'Ambiguous Perception'. The three transitions with greatest strength of association to base rate ratios are 'Incorrect Interpretation' to 'Search for Travel Companions' (df, R =

49.27), ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (mn, R = 14.56), and ‘Receive Instructions’ to ‘Follow Instructions’ (hj, R = 10.88).

Figure 12. Decomposition diagram showing strength of association between actions taken by participants over 60 years of age during the evacuation of the Costa Concordia



The standardised route described in this decomposition diagram depicting actions taken by participants over 60 is a-e-e. This route shows an immediate and terminal propensity to ‘Follow Others’. The three transitions with greatest strength of association to base rate ratios are ‘Incorrect Interpretation’ to ‘Follow Others’ (de, R = 92.42), ‘Initiate Evacuation

Process’ to ‘Encounter Evacuation Problems’ (mn, R = 32.74), and ‘Follow Others’ to ‘Follow Others’ (ee, R = 31.67).

A comparison of these diagrams would suggest that as age increases, there is increased variability in the reported actions. Once unambiguous perception is achieved, younger and older sub-cohorts report experiencing negative feelings. The middle sub-cohort shows the most certain route with respect to strengths of association. They tend to report ‘Ambiguous Perception’ followed by an Incorrect ‘Interpretation’ leading them to ‘Search for Travel Companions’ before attaining ‘Unambiguous Perception’. It is the eldest sub-cohort which shows the greatest strength of association for following others even as an initial action. This is somewhat corroborated by an increased tendency to follow instructions, instead of acting autonomously, with age. It also appears that reports of having problems evacuating increased with age.

With respect to the standardised analysis, no sub-cohort provides a complete route, based on the greatest strength of association, from beginning to end. All end abruptly or loop around before instructions are received. There is only one transition shared as important between two sub-cohorts. This is the ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (transition ‘mn’) demonstrated in the older two cohorts. As stated above, this transition is most important in the entire cohort and again highlights the importance of the way in which stories are told. Although it was rare to ‘Encounter Evacuation Problems’, if such problems were encountered, they were reported with an unexpectedly high frequency.

4.3.3 Companions

The complete cohort of 53 participants consisted of 6 participants who travelled alone, 32 who travelled with others, and 15 who travelled with their children. The frequencies of acts of each sub-cohort were recorded (see Table 7).

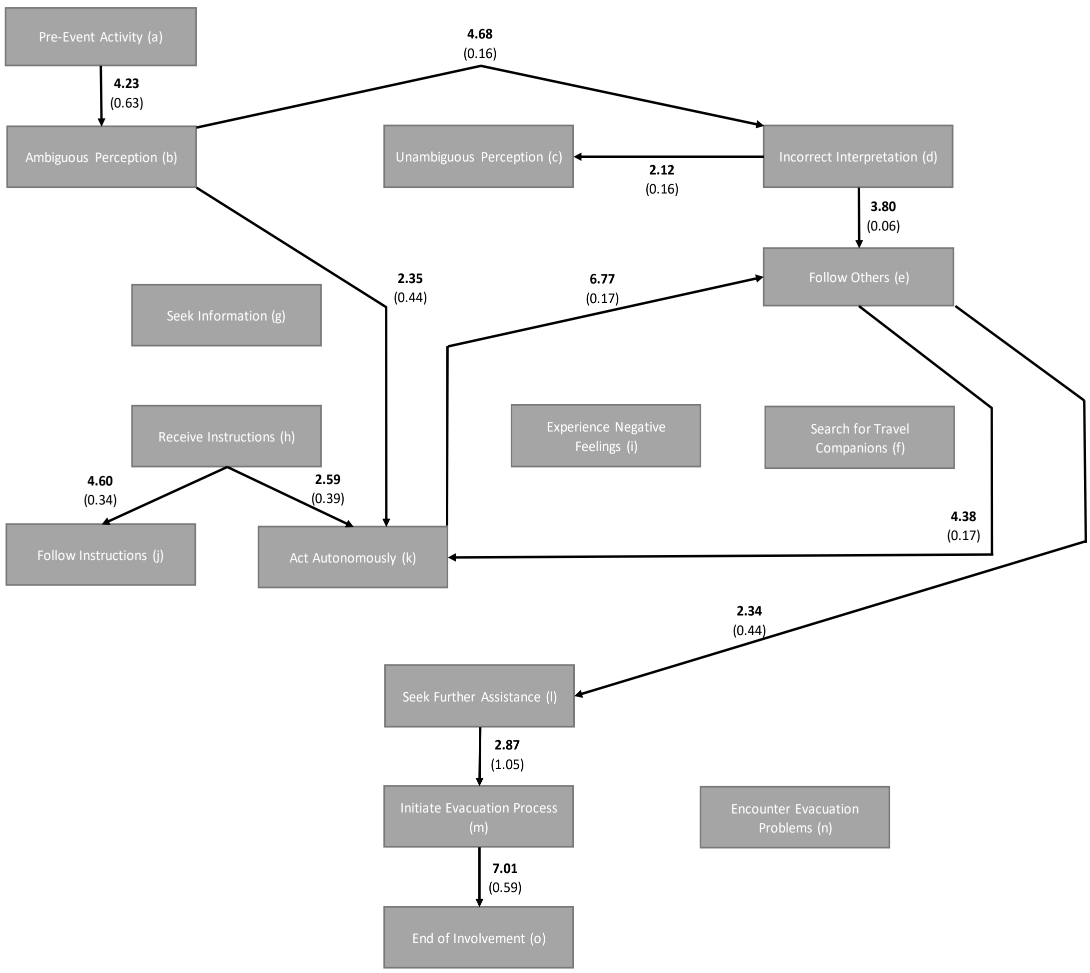
Table 7. Frequency comparison between passengers travelling alone, with others (friends, partners, family other than children) and with children

Act	Alone	Others	Children
Pre-Event Activity	6	32	15
Ambiguous Perception	7	39	20
Unambiguous Perception	10	40	17
Incorrect Interpretation	2	7	4
Follow others	6	12	8
Search for travel companions	1	14	5
Seek for information – Investigate	7	21	8
Receive Instructions	6	34	17
Experience Negative Feelings	3	34	15
Follow Instructions	7	25	4
Disregard Instructions – Act Autonomously	11	18	12
Seek further assistance	6	56	27
Initiate evacuation process – Board lifeboats	6	41	15
Encounter evacuation problems	6	11	3
End of Involvement – Abandon Ship	6	32	15

A Shapiro-Wilk test showed the frequency of acts for each sub-cohort to be normally distributed (Alone: $W(13) = 0.913$, $p = .201$; Others: $W(13) = 0.944$, $p = .507$; Children: $W(13) = 0.929$, $p = .329$). Pearson correlation analysis was undertaken which showed significant correlations between the frequencies with which similar experiences were reported by those who travelled either with others or with children ($r(11) = .91$, $p < .001$). However, no significant correlations were found with those who travelled alone.

Decomposition diagrams were then constructed for each sub-cohort (see Figures 13, 14 and 15).

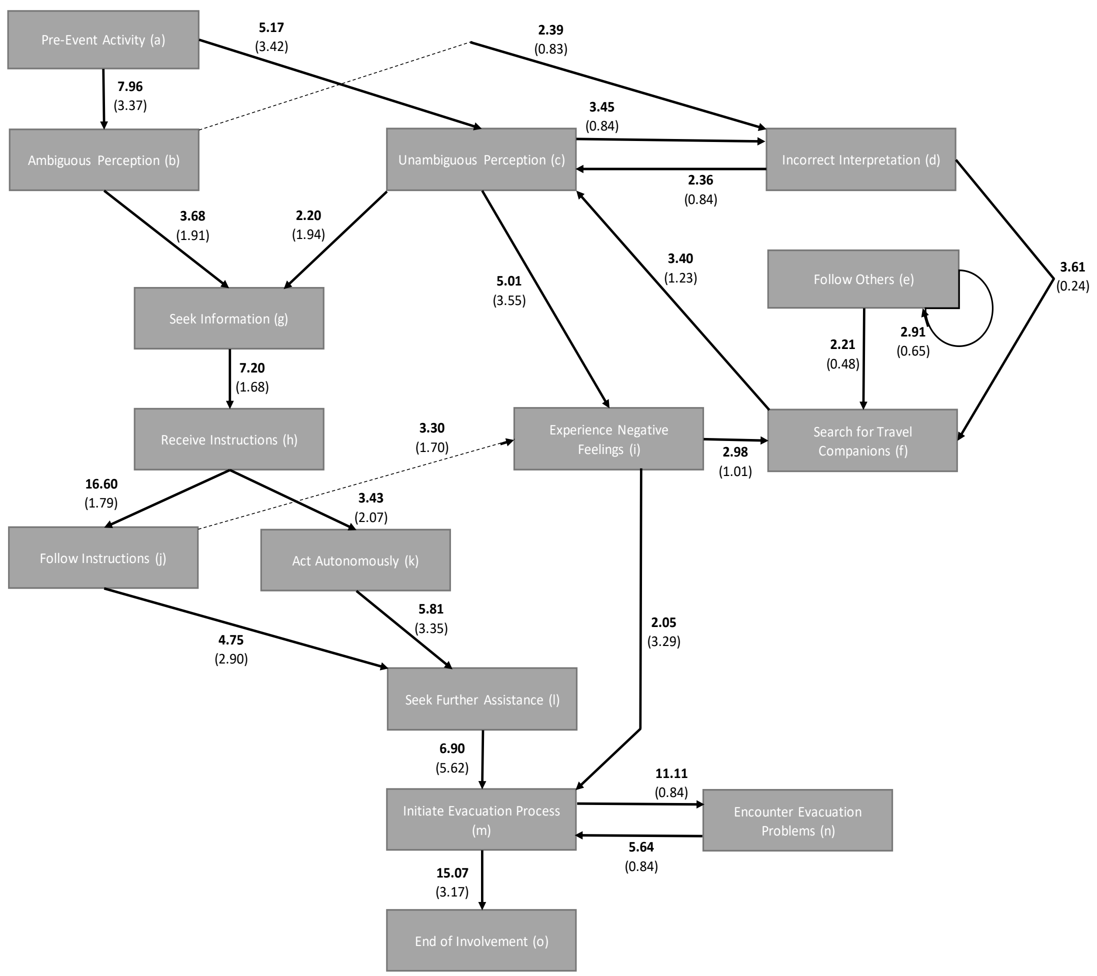
Figure 13. Decomposition diagram showing strength of association between actions taken by participants who travelled alone during the evacuation of the Costa Concordia



The standardised route, meaning a route going from ‘Pre-Event Activity’ based on the greatest strength of association until either ‘End of Involvement’ or an act, described in the decomposition diagram showing actions taken by participants who travelled alone is a-b-d-e-k-e. This route terminates with a loop between ‘Follow Others’ and ‘Act Autonomously’. It avoids the seemingly necessary nodes of ‘Unambiguous Perception’ and ‘Receive

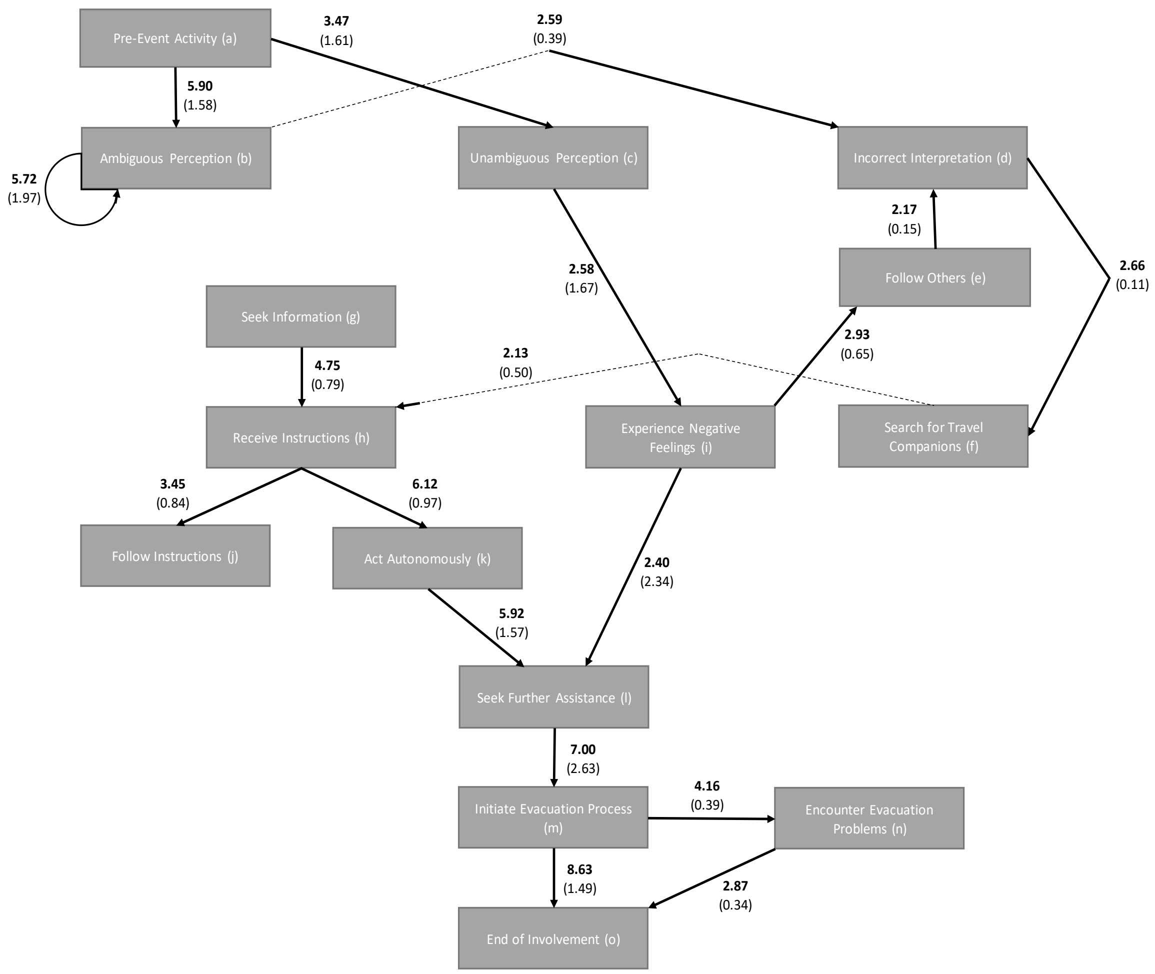
Instructions'. The three transitions with greatest strength of association to base rate ratios are 'Incorrect Interpretation' to 'Follow Others' (de, R = 63.33), 'Act Autonomously' to 'Follow Others' (ke, R = 39.82), and 'Ambiguous Perception' to 'Incorrect Interpretation' (bd, R = 29.25). These important transitions mirror the standardised route. However, it must be noted that this sub-cohort is the smallest recorded. This means the pro-rated 'expected values', and thus the pro-rated 'base rates', will exaggerate the importance of those acts and transitions reported by such a relatively small group.

Figure 14. Decomposition diagram showing strength of association between actions taken by participants who travelled with others during the evacuation of the Costa Concordia



The standardised route, a route going from 'Pre-Event Activity' based on the greatest strength of association until either 'End of Involvement' or an act, described in the decomposition diagram showing actions taken by participants who travelled with others is a-b-g-h-j-l-m-o. The route outlines the acts that navigate the evacuation from beginning to end. It avoids the social interaction nodes. This is evidence for the proposition that those already in a group tend to act as a unit. The three transitions with greatest strength of association to base rate ratios are 'Incorrect Interpretation' to 'Search for Travel Companions' (df, R = 15.04), 'Initiate Evacuation Process' to 'Encounter Evacuation Problems' (mn, R = 13.23), and 'Receive Instructions' to 'Follow Instructions' (hj, R = 9.27). It is interesting that the top two important transitions are not part of the implied route. However, it would be expected that the most important transition would include the 'Search for Travel Companions' in order to complete the aforementioned unit. The importance of transitions 'mn' and 'hj' are further evidence for the importance with which conditional acts affect the route of storytelling. Transition 'hj' was part of the implied route of evacuation, yet transition 'mn' was not. If an agent 'Receives Instructions' it is natural to report a reaction to such an outside event, that is the receipt of information from an authoritative other. Similarly, once evacuation is initiated, it is natural to report problems as an intervening act if, and only if, they were encountered. However, it is important to partition the role of 'choice' when interpreting acquired information in transition 'hj' versus the 'adaptation' involved in dealing with problems demonstrated in transition 'mn'.

Figure 15. Decomposition diagram showing strength of association between actions taken by participants who travelled with children during the evacuation of the Costa Concordia



The standardised route, a route going from 'Pre-Event Activity' based on the greatest strength of association until either 'End of Involvement' or an act, described in the decomposition diagram showing actions taken by participants who travelled with children is a-b-b. The route abruptly ends with a loop around 'Ambiguous Perception'. The three transitions with greatest strength of association to base rate ratios are 'Incorrect Interpretation' to 'Search for Travel Companions' (df, R = 24.18), 'Follow Others' to

‘Incorrect Interpretation’ (ed, R = 14.47), and ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (mn, R = 10.67). The first two of these important transitions revolve around incorrect interpretations which mirror the implied route’s termination at ‘Ambiguous Perception’. This may be seen as evidence for those with children requiring absolute certainty before initiating other evacuation acts. The third most important transition is the ‘conditional intervening consequence’ transition ‘mn’.

In summary, the strengths of association for those who travelled alone should be approached with caution. In addition to weak correlations with other sub-cohorts, the number of participants was comparatively small. However, there still appears to be a balance between acting autonomously and following others in order to achieve evacuation. Comparison between those who travelled with others versus those with children seemed to show two main differences. Those with children showed a strong association for either reporting immediate unambiguous perception or not at all. Those travelling with others seemed to report more balance between immediate unambiguous perception and following others and seeking travel companions before attaining such perception. This is somewhat mirrored by reactions to receiving instructions. Those travelling with others showed the strongest association with following the instructions. Those travelling with children were more likely to have acted autonomously.

In terms of the standardised analysis, similarities between those who travelled alone and those with children were reported. They share transitions ‘df’ and ‘mn’ as important. These are present even though neither appeared in the different respective standardised routes through evacuation. Transition ‘df’, from ‘Incorrect Interpretation’ to ‘Search for Travel Companions’, demonstrates the importance of unifying pre-existing groups before further action is taken. Transition ‘mn’, from ‘Initiate Evacuation Process’ to ‘Encounter Evacuation

Problems', demonstrates the role of conditional intervening events on the storytelling involved in reports of survivors.

4.3.4 Experience

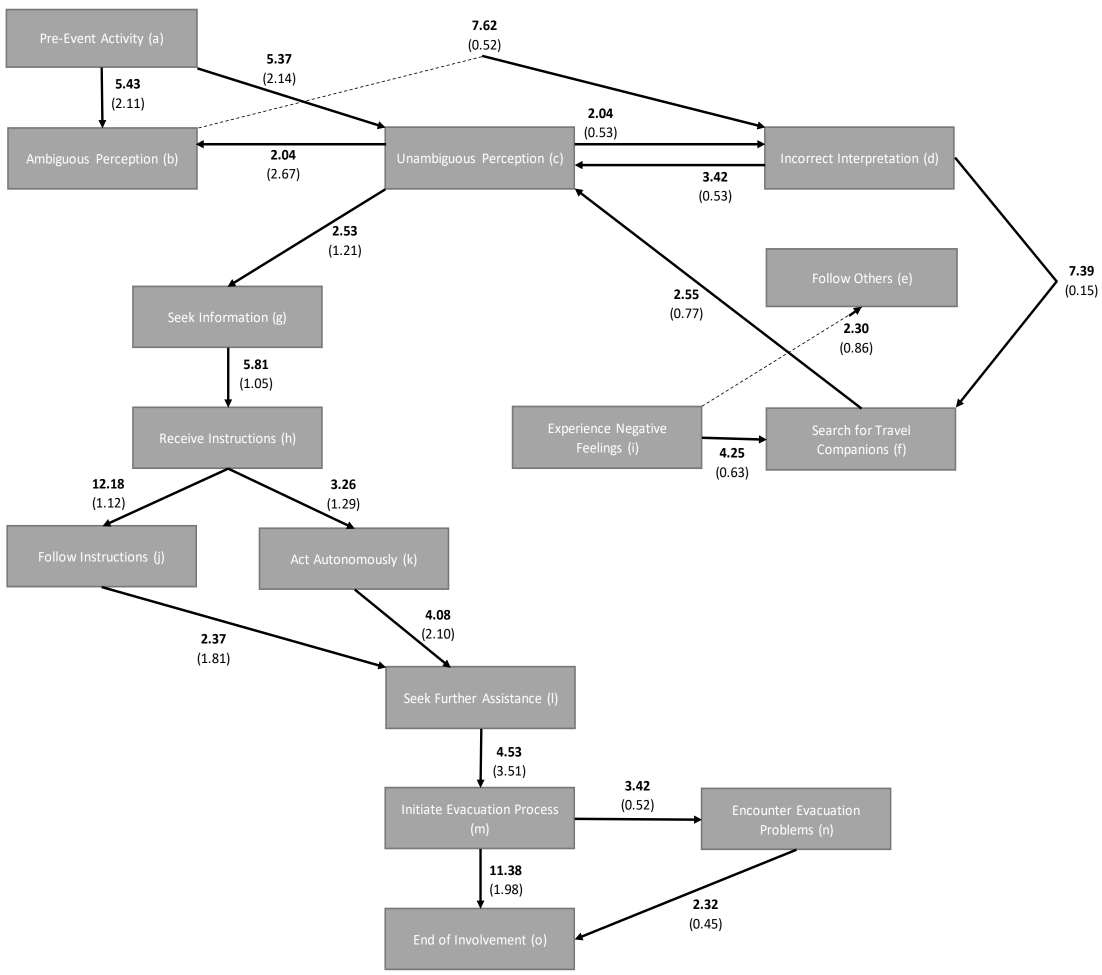
The complete cohort of 53 participants consisted of 20 participants who had previous experience travelling on a cruise ship, and 33 who did not. The frequencies of acts of each sub-cohort were recorded (see Table 8).

Table 8. Act frequency comparison between passengers with previous experience on cruise ships and passengers with no previous experience

Act	Previous Experience	No Experience
Pre-Event Activity	20	33
Ambiguous Perception	23	43
Unambiguous Perception	28	39
Incorrect Interpretation	10	3
Follow others	9	17
Search for travel companions	11	8
Seek for information – Investigate	13	17
Receive Instructions	24	34
Experience Negative Feelings	19	36
Follow Instructions	14	18
Disregard Instructions – Act Autonomously	13	24
Seek further assistance	31	63
Initiate evacuation process – Board lifeboats	21	41
Encounter evacuation problems	3	11
End of Involvement – Abandon Ship	20	33

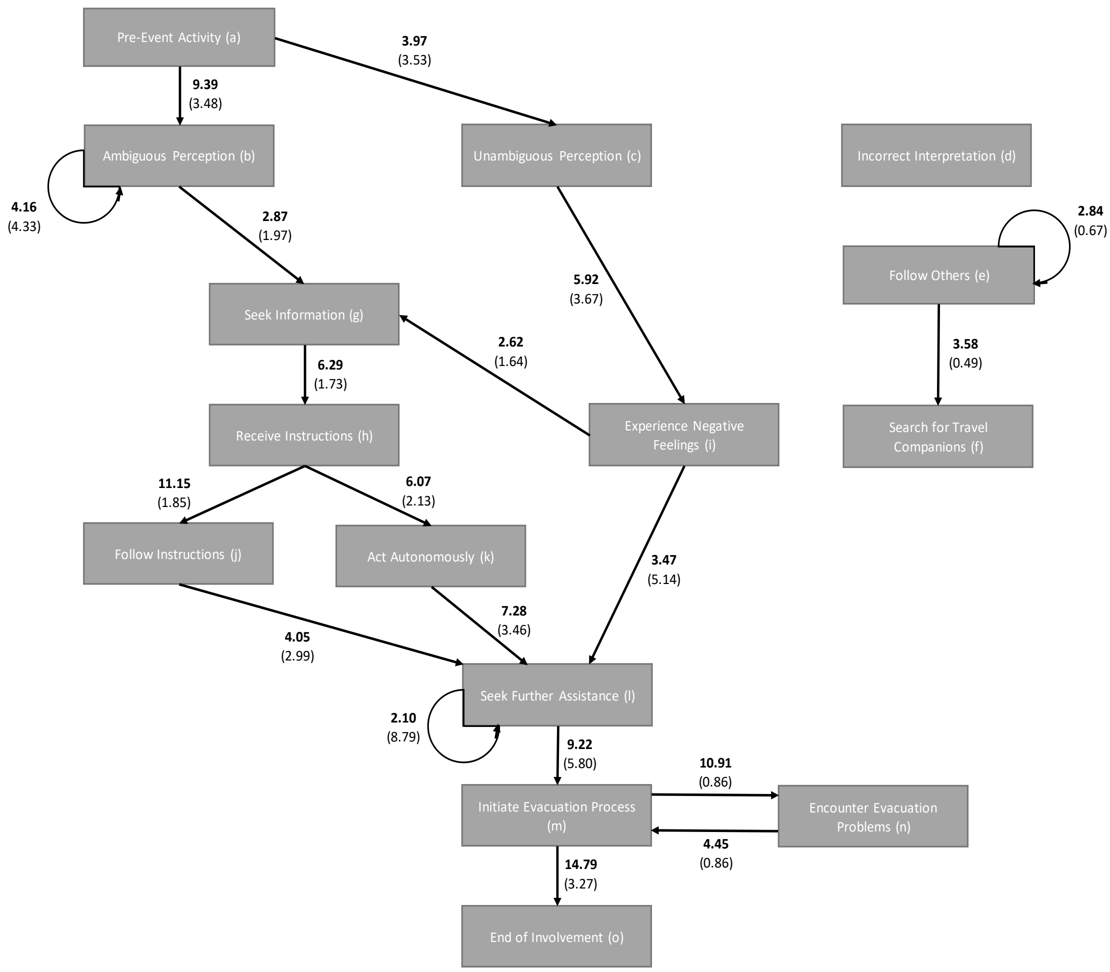
A Shapiro-Wilk test showed the frequency of acts for each sub-cohort to be normally distributed (Experience: $W(13) = 0.967$, $p = .859$; No Experience: $W(13) = 0.951$, $p = .616$). Pearson correlation analysis was undertaken which showed a significant correlation between the frequencies with which similar experiences were reported by each experience group ($r(11) = .90$, $p < .001$). Decomposition diagrams were then constructed for each sub-cohort (see Figures 16 and 17).

Figure 16. Decomposition diagram showing strength of association between actions taken by participants with previous experience during the evacuation of the Costa Concordia



The standardised route, a route going from ‘Pre-Event Activity’ based on the greatest strength of association until either ‘End of Involvement’ or an act, for participants with previous experience shown in Figure 16 is a-b-d-f-c-g-h-j-l-m-o. This route demonstrates a complete navigation through evacuation. The three transitions with greatest strength of association to base rate ratios are ‘Incorrect Interpretation’ to ‘Search for Travel Companions’ (df, R = 49.27), ‘Ambiguous Perception’ to ‘Incorrect Interpretation’ (bd, R = 14.65), and ‘Receive Instructions’ to ‘Follow Instructions’ (hj, R = 10.67).

Figure 17. Decomposition diagram showing strength of association between actions taken by participants with no previous experience during the evacuation of the Costa Concordia



The standardised route, a route going from ‘Pre-Event Activity’ based on the greatest strength of association until either ‘End of Involvement’ or an act, for participants without previous experience shown in Figure 17 is a-b-b. This route terminates abruptly with a loop around ‘Ambiguous Perception’. This would perhaps be expected due to previous inexperience. The three transitions with greatest strength of association to base rate ratios are ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (mn, R = 12.69), ‘Follow Others’ to ‘Search for Travel Companions’ (ef, R = 7.31), and ‘Receive Instructions’ to ‘Follow Instructions’ (hj, R = 6.03).

Predictably, the sub-cohort with previous experience show a more balanced strength of association for reporting ambiguous versus unambiguous perceptions of the situation. The sub-cohort with no previous experience report many more ambiguous perceptions. Once they attain unambiguous perception, and report the negative feelings associated with it, their accounts showed high strengths of association with seeking further assistance. Those with previous experience seemed more likely to follow instructions. They also seemed to avoid experiencing problems with evacuation.

4.3.5 Summary of Results of Study 1

The results of the standardised analysis of all decomposition diagrams were collected and collated for ease of comparison. (See Table 9). As can be seen, the expected intra-cohort variability is apparent, suggesting that different types of passengers behave differently. Similarly, the expected variability between sub-cohorts and the results of the entire cohort are clear to see. These differences exist in both the routes implied by the strengths of association between acts and the transitions shown to be important through the ratios of strengths of association to base rate calculations.

Table 9. Summary of implied routes and important transitions visible in Study 1 decomposition diagrams (Figures 7 to 17)

Cohort	Sub-cohort	Implied Route	Important Transitions		
			1st	2nd	3rd
All	-	a-b-d-c-i-l-m-o	mn	hj	mo
Gender	Male	a-b-b	hj	mn	ef
	Female	a-b-d-f-c-i-h-j-i	df	mn	de
Age	<41	a-b-d	ef	bd	mo
	41 to 60	a-b-d-f-c-b	df	mn	hj
	>60	a-e-e	de	mn	ee
Companions	Alone	a-b-d-e-k-e	de	ke	bd
	Others	a-b-g-h-j-l-m-o	df	mn	hj
	Children	a-b-b	df	ed	mn
Experience	Previous	a-b-d-f-c-g-h-j-l-m-o	df	bd	hj
	None	a-b-b	mn	ef	hj

With respect to the implied routes, it is interesting to note that only two of the ten sub-cohorts displayed a complete navigation through the evacuation, with strong strength of associations to “End of Involvement”, in the same way that the entire cohort did. Furthermore, it is interesting that none of these routes are identical. It must be remembered that the calculations of expected values for sub-cohorts were based on pro-rated entire cohort values. This was intended to highlight differences between sub-cohorts and the most complete view of what was to be expected. Thus, these results suggest that those who travelled with others and those with previous experience of travelling by cruise ship act in the most expected way, in the same way as the entire cohort did.

The differences from the entire evacuation sequence described by the entire cohort are most apparent in the most truncated routes. These show that males are inclined to report successive ‘Ambiguous Perceptions’, suggesting that males assess risk less severely than females. Results also suggest younger people form incorrect interpretations of events while older people immediately choose to follow others. As described above, it seems those who travel with others act as an efficient unit while those with children, similar to males, tend to report a focus on ‘Ambiguous Perceptions’. Finally, those with previous experience on cruise ships seem to demonstrate a thoroughly efficient navigation through evacuation. However, the sub cohort without previous experience, similarly to males and those travelling with children, become aware of repeated ‘Ambiguous Perceptions’.

With respect to the most important transitions, those demonstrated by the entire cohort were focused on external events: the receipt of instructions and the ease of final evacuation. It is encouraging to note that no sub-cohort shared all three of these transitions. One transition which consistently stands out as important involves the ‘Search for Travel Companions’ once there has been an ‘Incorrect Interpretation’ (transition ‘df’). This is displayed as the most important transition for females, mid-ages, those travelling with others or children, and those with previous experience. This transition also appears in the implied routes of sub-cohorts which were not immediately terminated by repetition. The behavioural transition of seeking for travel companions following an incorrect interpretation suggests that people seek for confirmation of risk from family or friends. These finding hints that without clear information and instructions, passengers will invest time and effort in behaviours that are not beneficial to the end of evacuation.

Of perhaps even greater significance to the aims of this thesis is the consistent appearance of transition ‘mn’, ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’. It is the most important transition in the entire cohort and is visible in at least one sub-cohort in all conditions. However, it does not appear in a single standardised route. Furthermore, upon inspection of all previous decomposition diagrams, it is only apparent in those over the age of 60 that there was a greater strength of association with encountering problems with evacuation. The individual transitions reported showed the greatest strength of association to base rate ratio, the ‘base rate’ guards against acts which were observed many times seeming to show high strengths of association based merely on their prevalence. This would imply that although encountering problems with evacuation was not a common and therefore expected behaviour, when it happened it was reported at a much higher level than expected.

4.4 Discussion of Study 1

4.4.1. Study 1 – Comparison with Canter and Finiti (2015)

Initial comparison of data collected for this study versus that of Canter and Finiti (2015) showed significant similarities through high correlations. This finding is especially encouraging as the taxonomy of acts for this thesis was created independently from that of the previous study. This provides good evidence that the generalised taxonomy of acts is capable of describing the discrete states, which combine to form sequences of acts during maritime evacuations. This may be transferrable to other evacuation scenarios. Even though there were minor differences in acts reported, the correlations found for those identical acts were strong enough to compensate. This would suggest that the methodology is collecting information of a similar standard. The significant correlations would imply that acts reported were of a similar granularity, describing a similar trajectory in collected accounts of two separate cohorts experiencing the same scenario. These conclusions would all point to the present study showing good validity and reliability.

In terms of different measures of validity (Howitt & Cramer, 2011), the area under investigation is evacuation in emergency scenarios. This study examined accounts of such a scenario, thus demonstrating face validity. Concurrent validity is demonstrated by the significant correlations found between results of this study and the previous study by Canter and Finiti (2015). This would imply there also to be predictive validity. Similarly, the studies both concerned cohorts involved in a real-life emergency scenario, thus demonstrating ecological validity.

4.4.2. Study 1 – Behavioural Sequence Analysis of Real-Life cohort

Correlation analysis measured the similarity in the number of different types of acts reported. It demonstrated reports to consist of a similar granularity of description involving a similar number of similar acts. However, in order to undertake analysis of the sequences contained in accounts, Behavioural Sequence Analysis is used to show strengths of association between adjacent reported acts. These associations can then be mapped to create a decomposition diagram showing a quantitative evaluation of the likelihood of one act leading to another within variable routes used to navigate through a scenario. The results shown for the entire real-life cohort are encouraging (see Figure 7). Visual inspection of the decomposition diagram shows a sensibly ordered route of strong transitions between certain acts. When taking into account standardised residuals versus base rates, it becomes apparent that a clear route exists in the initial stages of an evacuation between 'Pre-Event Activity' and 'Unambiguous Perception'. Following the strongest standardised residual to base rate ratios leads from 'Pre-Event Activity' to 'Ambiguous Perception' to 'Incorrect Interpretation' to 'Unambiguous Perception'. It is not unreasonable to suggest that, if someone were to imagine the initial stages of a disaster scenario, this is the expected sequence of acts involved in the 'dawning of realisation'. This chain of events demonstrates good face validity. It seems the logical route, and it is clearly visible, and detectable from a simple statistical rule, in the results of this scientific examination.

It is also encouraging that the entire cohort demonstrates a complete route of evacuation based on the greatest strengths of association between adjacent acts. However, following this clear 'dawning of realisation' chain of events the strengths of association and comparisons with appropriate base rates become less clear. 'Unambiguous Perception' proves to be the precursor to variable behaviour. This 'Unambiguous Perception' node (c) is the most connected in the decomposition diagram. In total, it shows a notable strength of association with six other acts, three as a subsequent act and three as a preceding act. As a subsequent act, it shows a notable strength of association with 'Pre-Event Activity' (a), 'Incorrect Interpretation' (d), and 'Search for Travel Companions' (f). These transitions would seem to be evidence for three different types of passengers. There are those who apprehend a problem immediately (ac), those who demonstrate delayed understanding (dc), and those whose priority is to gather travel companions as soon as they realise 'something' is wrong (fc). That such different reactions can be seen in the entire cohort demonstrates the need for trait analysis to examine these differences.

Similarly, the acts which 'Unambiguous Perception' precedes show variability. Again, there are three acts which demonstrate notable strengths of association as subsequent acts, 'Incorrect Interpretation' (d), 'Seek Information' (g), and 'Experience Negative Feelings' (i). It is the first of these which is perhaps unexpected. It seems strange that a report of 'Incorrect Interpretation' would follow a reported 'Unambiguous Perception'. However, this may be evidence for certain passengers showing a heightened amount of caution when confirming circumstances. The other two transitions of note are more expected but still demonstrate differences between the reactions of passengers. In terms of strength of association, the greatest is with 'Experience Negative Feelings (Transition 'ci', SoA = 5.4).

This is then followed by ‘Seek Information’ (Transition ‘cg’, SoA = 2.67) and then ‘Incorrect Interpretation’ (Transition ‘cd’, SoA = 2.21). That the strength of association towards ‘Experience Negative Feelings’ is approximately double those of the other transitions is interesting with respect to the role of storytelling. Attaining awareness of a potentially dangerous situation is perhaps an understandable point at which to report emotional reactions. However, as stated earlier, it is not an ‘act’ per se, but rather exists as a notation of a consistently reported item within a story.

Of further interest is the importance of these transitions. When compared to the base rates, the transitions to ‘Experience Negative Feelings’ (Transition ‘ci’, SoA = 5.40, BR = 5.89) and ‘Seek Information’ (Transition ‘cg’, SoA = 2.67, BR = 3.21) actually occurred fewer times than would be expected. In general, social acts and reports of emotions seem to occur with similar strengths as information seeking. Again, this would hint at differences in types of passengers, and, indeed, differences in storytelling.

The strength of association to base rate ratio seems valid as a measure of the importance of a transition. That is, if certain acts occur, they are reported with an unexpectedly high prevalence. Indeed, this is further compounded by the realisation that the peak strength of association to base-rate ratio apparent during these intervening events is visible in the following of received instructions. This transition, ‘hj’ (Receive Instructions to Follow Instructions), as stated earlier, is not a part of the standardised route of evacuation described by strength of associations. Instead, when looking at transitions which showed the greatest strength of association to base rate ratio, it sits apart from analysis. Furthermore, the isolated nature of this calculation of importance is evident as high ratios are not again apparent until initiation of evacuation. This would seem to hint at the existence of certain necessary transitions.

The availability of different ways through which the data in decomposition diagrams can be analysed allows for multiple interpretations of data. However, when attempting to provide strong evidence for implementation into computational models, it is problematic. A cellular model requires a certain quantitative measure which directs actions. A current limitation in the methodology of behavioural sequence analysis is that it only analyses individual parts of sequences of acts, transitions.

It is possible to gain an understanding of the statistical construction and prediction of a sequence of acts, but no insight is provided into the more analytical issue of why these acts occurred in such a sequence. One possible method for attaining such information would be to ask each participant to re-live the disastrous events. However, on a purely ethical basis this must be discounted. Even on a pragmatic basis, the information collected would be subject to a multitude of possible flaws with respect to inaccurate and rationalised memories (Wood, 1980). Overall, the results provide evidence for the usefulness of behavioural sequence analysis for outlining an approximation of a group evacuation. However, there exist issues with the data outputs that the methodology provides. Strengths of association between acts in a non-controlled sequence represent a relative conditional probability. Further research should focus on establishing controlled probabilities of transitions between the types of acts described in the generalised taxonomy. Additionally, it can be seen in the visualisation of the complete cohort that there are intra-cohort differences. This seems to suggest that there are different types of passengers. The method used in this study to attempt to gain insight into the analytics of the situation is through comparing categorised members of the cohort.

4.4.3. Study 1 – Trait Analysis of Real-Life Cohort

Trait analysis was conducted for three primary purposes. Firstly, microscopic models of behaviour are developed from individuals rather than a group. The first step towards individuality is to break down the entire cohort into trait-based categories. Secondly, in order for a psychological behavioural decision-making model to be compatible with a computational model of action, results need to be reoriented towards providing insight into the value by which a change in input will affect a computational output. An example of an appropriate input is a difference between males and females in mean walking speeds (Bohannon, 1997). Another is the various mean-times recorded in the completion of certain vital actions (Lawson, 2011). In the present study, no accurate appropriate output variable is available. This would involve an accurate report of exactly how long it took each survivor to move from pre-event activity to end of involvement. As previously noted estimates of such timings provided by participants in an emotionally charged situation are not necessarily accurate (Lawson, 2011).

The third purpose of trait analysis is to further uncover within-cohort differences undetected by correlation analysis or through examination of a decomposition diagram of an entire cohort. It is enlightening, but simultaneously highlights the possibility of potential contradictions evidenced by different forms and levels of analysis. Indeed, certain differences between sub-cohorts were immediately apparent. Examination of these differences allows for a form of reverse engineering of an explanation of 'why' actions were taken. Certain between-sub-cohort differences were apparent, for example females seeming more risk averse and aware of their surroundings. These differences will be discussed in detail at a later point (Chapter 6, Study 3)**.**

4.4.4. Conclusions

The replication of the previous study (Canter & Finiti, 2015) was the first successful replication of a Behavioural Sequence Analysis method applied to an evacuation during a maritime emergency scenario. The methodology produced similar findings from a different sample of the population of survivors of the Costa Concordia disaster. This goes some way to filling a gap in knowledge reported by Lawson (2011). Further analysis demonstrated a statistically strong chain of events during the initial phase of evacuation. However, there also seemed to be evidence of certain necessary transitions. Additionally, further analysis was able to detect within-cohort differences based on categorical trait differences. Prima facie, these results demonstrate good validity and reliability of the methodology used in the present study. However, it became apparent that different levels of analysis may uncover contradictions. Furthermore, it highlighted the need for reorientation of the current method towards providing data compatible with computational modelling.

Chapter Five: An Assessment of the 'Talk-Through' Method

5.1 Study 2 – Replication of a Real-Life Study using Imagined Accounts.

5.1.1 Introduction

Lawson (2011) and Lawson et al. (2009a, 2009b, 2013) developed and attempted to validate the talk-through approach in several studies. The results consistently found statistically significant relationships with Canter's (1980) study of behaviour in domestic, multiple occupancy and hospital fires. However, even though statistically significant relationships were found, noteworthy variations were also present. Whilst giving an indication of possible human behaviour in fires, the approach did not produce predictions accurately representative of human behaviour in real fire emergency situations. An important limitation to the validation of the talk-through method conducted by Lawson et al. (2013) is the reference study used to compare results. The data used by Canter (1980) included survivor accounts from various fires, meaning different events and circumstances. As previously discussed, the environment in which the disaster occurs and the course through which the disaster evolves heavily influences decision-making in disaster scenarios (Aguirre et al., 2011). Human behaviour and decision-making in a disaster is specific to that disaster. Thus, the methodology of the present study is to recreate the specific situation of the Costa Concordia disaster in a safe environment. Constructing a more detailed scenario to be imagined by participants should promote the development of more detailed accounts. In turn, these accounts should allow for more accurate coding, richer data, and finer analysis. If successful, this may provide a possible route to the creation of high-quality data for rigorous examination.

5.1.2 Method

The method chosen for the present study is the talk through method, as presented in Lawson et al. (2013). It is a low-cost method, which consists of giving participants a description of a hypothetical emergency scenario and asking them to imagine and predict how they would behave. It allows the researcher to record participants' predicted reactions to a dangerous situation without putting them in real danger. It is of interest to compare how people believe they would behave and how people reported themselves to have behaved in the described situation. The goal of the study is to gain information on human behaviour in maritime emergencies through the comparison of participants' predictions of their behaviour in a maritime disaster and the data from individuals who actually experienced the event. Ultimately, the aim of this study is to provide corroborative evidence for 'imagined' studies to be as informative as 'real-life' studies. This in turn will be a more efficacious process for developing recommendations and guidance for human factors professionals responsible for behavioural organisation in emergency situations.

5.1.3 Participants

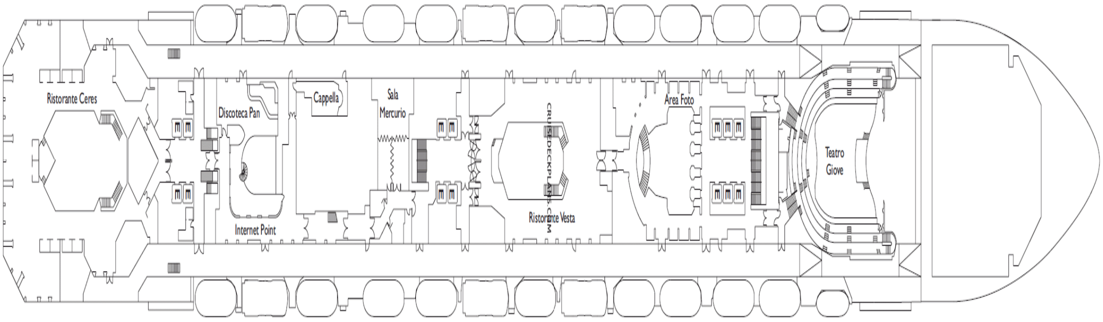
Participants were recruited at The Department of Human Neuroscience at Sapienza University of Rome. Students and staff were invited to take part in the study through adverts, which were published and shown at the end of lectures of the Criminology MSc. The leaflet advertised research on human behaviour in emergency situations and briefly explained the aims of the study. It was clearly stated that people who had been involved in, or affected by, serious emergency situations, and people suffering from poor mental health conditions, should not apply. These restrictions were applied to minimise the risk of causing any discomfort or distress during the experiment. The participants who met the criteria were provided with an information sheet regarding the study. This included free counselling contact information in case any distress or negative feelings were to arise during, or following, the interview. Additionally, consent forms were provided in which the participants' right to withdraw at any time was highlighted (See Appendix I). Accounts were recorded from 40 participants recruited from the students and staff of the Sapienza University of Rome. There were 18 males with a mean age of 39 years old. There were 22 females with a mean age of 38 years old.

5.1.3 Materials

Information packs containing pictures, plans and the layout of the Costa Serena cruise ship were supplied to participants. The Costa Serena is the sister ship of the Costa Concordia. It was chosen for the study due to the ships being practically identical in terms of ship design, layout, and deck plans. The pack included general pictures of the cruise ship, specific public areas such as restaurants, cafes, and clubs, deck plans (see Figure 18), cabin pictures and general emergency equipment layout.

Participants were allocated a one-hour appointment in a meeting room within The Department of Human Neuroscience. The room was equipped with a computer connected to a projector; other materials used included a laptop and a recording device.

Figure 18. Costa Serena Deck 4 - Orion



Note. Reprinted from https://s.krfb.de/decks/costa-serena-deck04-orion.dmpna0r9.png. In the public domain.

5.1.4 Procedure

Participants were given appointments that lasted approximately one hour. They were requested to read the information sheet and to sign the consent form before being provided with an information pack with the layout of the ship and pictures of common areas. They were asked to familiarize themselves with the ship through the images provided and to imagine they were on board. Before proceeding, participants were given time to become familiar with the cruise ship and to ask any questions. The narrative in Figure 19 was read to the participants as part of the talk-through method (Lawson et al., 2009).

Figure 19. Statement read to participants

Look at the material in the information pack provided and familiarise yourself with the ship.   Imagine you are on holiday on this cruise ship. You have only recently (less than 24hours) boarded the cruise ship and you notice that crew members don't speak Italian very well. Please list and describe the actions you would take in detail, keep in mind there are no right or wrong answers. Please report only the actions you predict you would be most likely to take. I may recommend you add some details if necessary.   Imagine that you are on the cruise ship. Who are you with? It's evening between 8 and 10pm. Where do you imagine yourself located at? What are you doing?   While you are ______ you hear strange noises, vibrations and oscillations followed by a black-out. Considering the context and the atmosphere you're experiencing (on holiday, having dinner, etc.) what stimulus would alarm you? What would you think was happening? Given this interpretation, what would you do next?

The general model of behaviour proposed by Canter et al. (1980) and validated in Canter and Finiti (2015) proposes a general model of behaviour during evacuations consisting of three key stages: interpret, prepare and act**.** It is therefore expected that people will imagine behaviour following this defined, temporal sequence. It is anticipated that each participant will receive the information, interpret it, prepare to take action through seeking information, searching for others, and receiving instructions, then take action through following or ignoring instructions. If participants' responses lacked sufficient detail, or skipped identified logical stages, they were prompted to add details to their predictions. Following the procedure described in Lawson et al. (2009), examples of the prompts used are: "I think you're missing something there" or "I'd like more detail about the stages between those acts". Whether the reports were missing details or steps was determined by knowledge of general acts identified across human behaviour in emergency literature and the act-sequences observed in the study conducted using reports from survivors. The hypothetical scenario ended when participants stated they had boarded a lifeboat and were out of danger. Every action predicted was recorded on a laptop computer and participants were given the chance to review their actions before ending the experiment. The predicted acts where coded against the taxonomy of acts developed from the survivor accounts in Study 1. Every act reported by participants was found to fit the original taxonomy and no new categories had to be created. An independent researcher reviewed the data to check for consistency and minimize researcher bias. The School Ethics Research Panel (SREP) of the School of Human and Health Sciences, University of Huddersfield has ethically approved the project.

5.2 Reliability Comparison with Study 1

Reliability is a measure concerned with achieving the same results using similar methodology (Wilson, 2005). As in Study 1, the coded acts were used to create an act matrix. This matrix was then used to create a transition matrix showing how any acts were succeeded and their strength of associations. The strength of association between acts was obtained by identifying the standardized residuals: observed frequency minus expected frequency, divided by the square root of expected frequency. This measurement allows for the identification of transitions occurring above the expected level of chance (Bakeman & Gottman, 1986). Higher positive standardized residuals indicate transitions happening more frequently than expected and negative values reflect transitions occurring less frequently than expected.

5.2.1 Analysis and Results

Each account was analysed individually and presented as a sequence of acts. The descriptions of actions were coded in accordance with the generalised taxonomy established in Study 1 (see Table 10).

Table 10. Generalised taxonomy of acts and the frequency with which they were reported

Code	Description	Frequency
a	Pre-Event Activity	40
b	Ambiguous Perception	51
c	Unambiguous Perception	52
d	Incorrect Interpretation	24
e	Follow others	22
f	Search for travel companions	31
g	Seek information	34
h	Receive Instructions	33
i	Experience Negative Feelings	36
j	Follow Instructions	19
k	Act Autonomously	17
l	Seek further assistance	55
m	Initiate evacuation Process	42
n	Encounter evacuation problems	8
o	End of Involvement	40

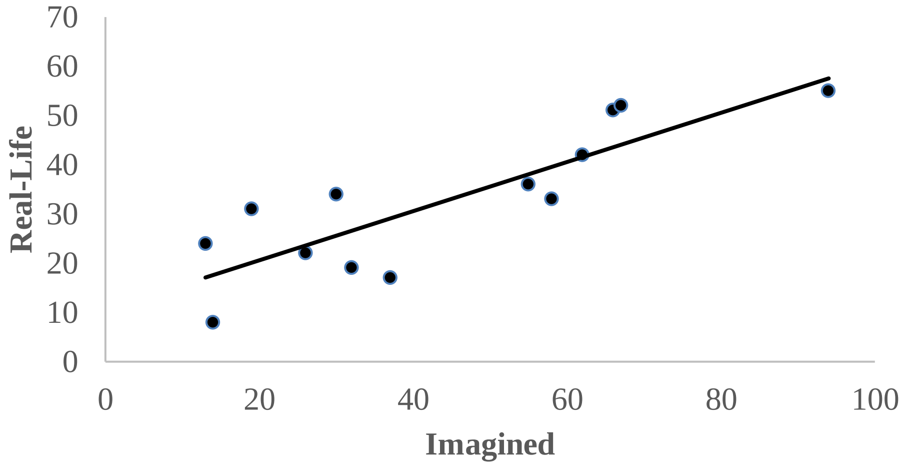
These overall counts from the ‘imagined’ study were then compared to the overall counts from Study 1, the ‘Real-Life’ study (see Table 11).

Table 11. Frequency comparison between 'Real-Life' and 'Imagined' accounts

Act	Real-Life	Imagined
Pre-Event Activity	53	40
Ambiguous Perception	66	51
Unambiguous Perception	67	54
Incorrect Interpretation	13	24
Follow others	26	23
Search for travel companions	19	34
Seek information	30	36
Receive Instructions	58	36
Experience Negative Feelings	55	41
Follow Instructions	32	23
Act Autonomously	37	18
Seek further assistance	94	55
Initiate evacuation process	62	42
Encounter evacuation problems	14	8
End of Involvement	53	40

A Shapiro-Wilk test showed the frequency of acts for each cohort to be normally distributed (Real-Life: $W(13) = 0.933$, $p = .415$; Imagined: $W(13) = 0.956$, $p = .655$). A Pearson correlation (see Figure 20) showed a significant correlation between the frequencies with which similar experiences were reported in real-life versus imagined scenarios ($r(11) = .84$, $p < .001$).

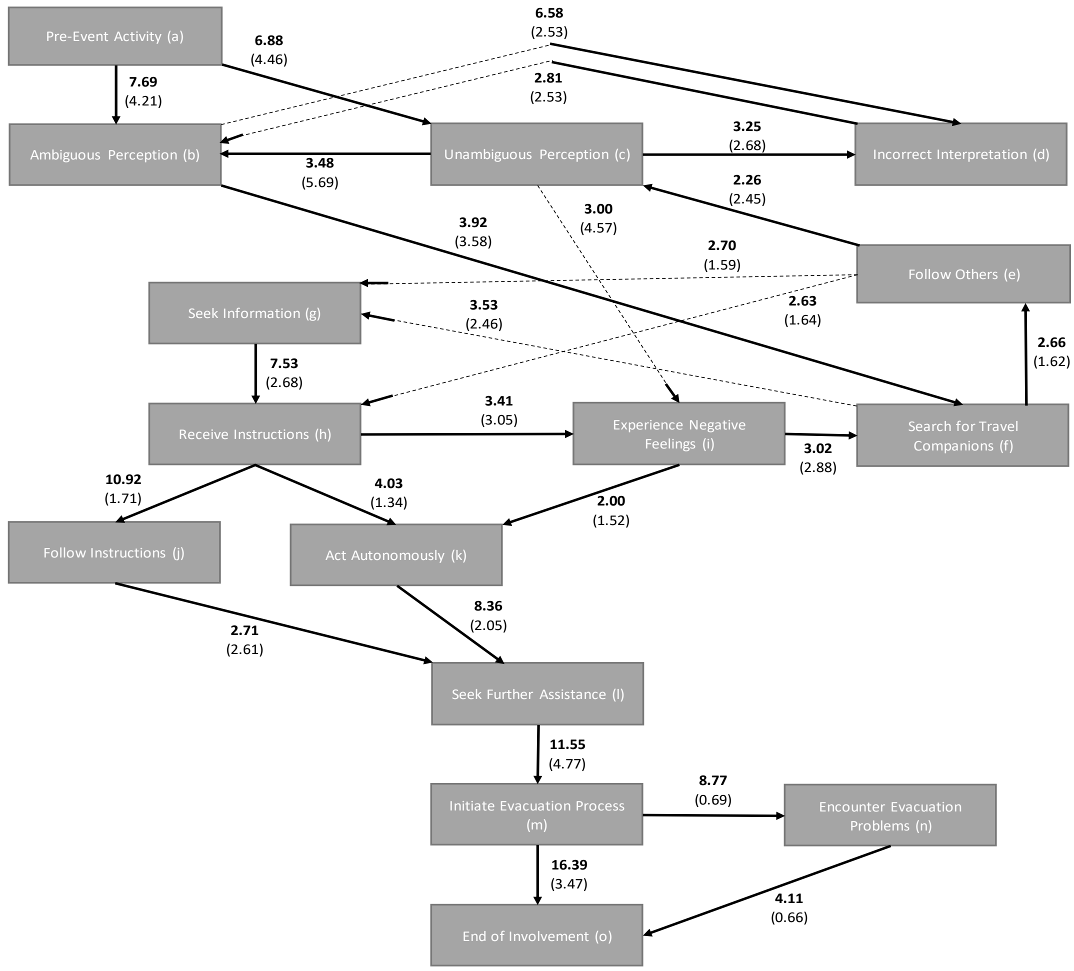
Figure 20. Scatterplot of comparison of frequencies of similarly reported actions between the present 'Imagined' study and 'Real-Life' study



5.3 Behavioural Sequence Analysis

Standardised residuals were calculated for the strength of associations between acts from the transition matrix. A value greater than '2' was considered to show strength, and the greater the value, the greater the strength. A decomposition diagram was constructed to show these strengths for the entire 'imagined' cohort (see Figure 21).

Figure 21. Decomposition diagram showing strength of association between actions imagined to be performed during the evacuation of the Costa Concordia



5.3.1 Analysis

As with the analysis of deconstruction diagrams performed in Study 1, due to the data-rich nature of these diagrams, similar standardised analysis of implied route (a route going from ‘Pre-Event Activity’ based on the greatest strength of association until either ‘End of Involvement’ or an act) and transition importance (transitions showing the greatest strength of association to base ratio) will be undertaken in combination with more interpretive analysis.

The standardised route of actions imagined to be performed during an evacuation described in Figure 21 is a-b-d-b. This route is ended by looping back to ‘Ambiguous Perception’. The three transitions with greatest strength of association to base rate ratios are ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (mn, R = 12.71), ‘Receive Instructions’ to ‘Follow Instructions’ (hj, R = 6.39), and ‘Encounter Evacuation Problems’ to ‘End of Involvement’ (no, R = 6.23).

The standardised route described in the decomposition diagram is truncated by a loop between ‘Ambiguous Perception’ and ‘Incorrect Interpretation’. This is perhaps understandable due to the lack of physical perceptual cues in the laboratory environment. However, this is a contrast to the decomposition diagram of the real-life cohort, which described a complete route through evacuation. The three transitions with highest ratios are similar to those found in the real-life cohort. In both conditions, transition ‘mn’ is first and transition ‘hj’ is second. The third highest ratio in the imaginary condition is transition ‘no’ rather than transition ‘mo’ observed in the real-life-cohort.

In each condition, the number of transitions visible is similar (Real-Life = 23, Imagined = 24). This is evidence for the overall numerical outputs of each method being similar when considered collectively. However, visual inspection reveals more links to social actions for those in the imagined scenario. In this condition, these actions seem to take place between ‘Ambiguous Perception’ and ‘Unambiguous Perception’. This contrasts with the real-life condition where there was a strong path from ‘ambiguous perception’ via ‘incorrect interpretation’ to ‘unambiguous perception’.

Again, it is interesting to note that two of the three most unexpectedly highly reported transitions include ‘Encounter Evacuation Problems’. From the low base-rate it can be inferred that this was not a highly reported imagined act. However, if this act was indeed imagined, it was subsequently reported at a highly unexpected rate.

5.3.2 Summary

Analysis of the correlation between the real-life and imagined scenarios would suggest there to be a significant similarity between the reporting of results by the different cohorts. Further evidence for this collective similarity is that a similar number of transitions which demonstrate a high strength of association are visible in the diagram for the entire cohorts in each condition. However, that the implied route through evacuation was truncated through looping around 'Ambiguous Perception' might suggest interviews would benefit from structured interventions, such as a recording of an announcement clarifying the situation being imagined. Further visual comparison of this decomposition diagram (Figure 21) with that of the real-life cohort (Figure 7) would suggest there to be apparent variability. These differences will be analysed thoroughly in Chapter 6.

5.4 Trait Analysis

As in Study 1, four traits were recorded for each participant: gender, age, companions, and previous experience. As this was an imagined study, whether the participants imagined themselves travelling with companions was established and noted before the study commenced. The coded accounts of the entire cohort were split into the appropriate categories and examined for potential differences. The 'expected frequency' of all calculations was the pro-rated frequency of the entire imagined cohort.

5.4.1 Gender

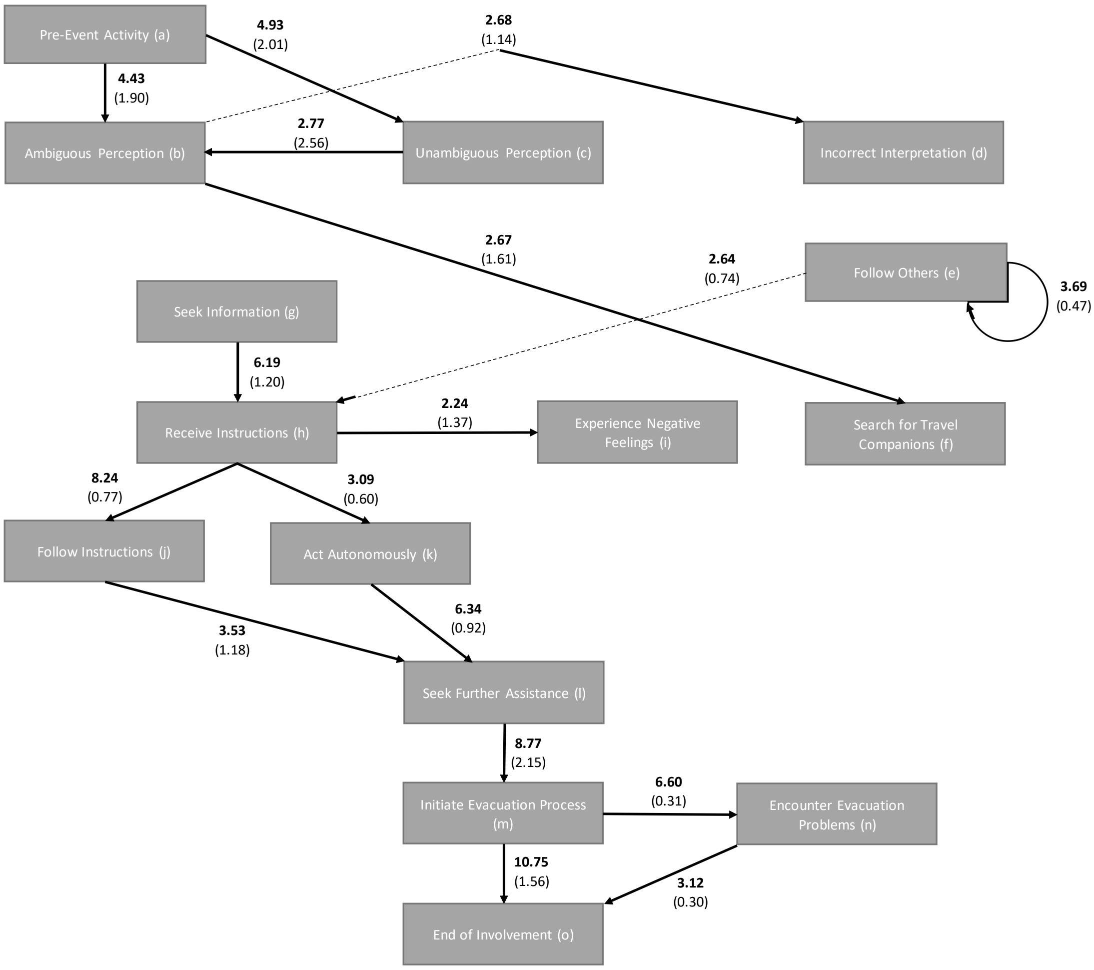
The complete cohort of 40 participants consisted of 18 males and 22 females. Initially, the frequencies of acts of each sub-cohort were recorded (see Table 12).

Table 12. Frequency comparison between male and female passengers in imagined scenario

Act	Male	Female
Pre-Event Activity	18	22
Ambiguous Perception	21	30
Unambiguous Perception	23	31
Incorrect Interpretation	9	15
Follow others	12	11
Search for travel companions	11	23
Seek for information – Investigate	15	21
Receive Instructions	17	19
Experience Negative Feelings	18	23
Follow Instructions	10	13
Disregard Instructions – Act Autonomously	9	9
Seek further assistance	25	30
Initiate evacuation process – Board lifeboats	19	23
Encounter evacuation problems	4	4
End of Involvement – Abandon Ship	18	22

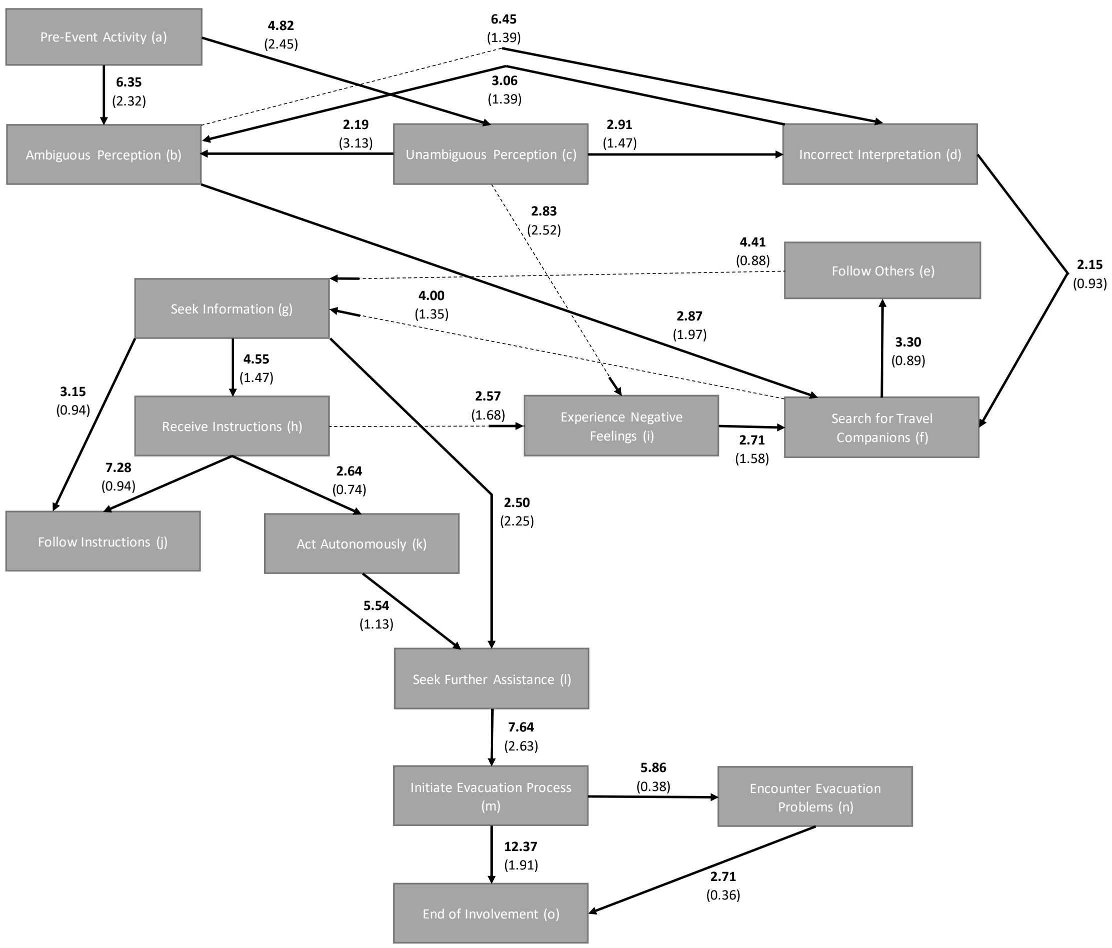
A Shapiro-Wilk test showed the frequency of acts for each sub-cohort to be normally distributed (Males: $W(13) = 0.969$, $p = .881$; Females: $W(13) = 0.948$, $p = .568$). A Pearson correlation was undertaken which showed a significant correlation between the frequencies with which similar experiences were reported by males and females ($r(11) = .91$, $p < .001$). Decomposition diagrams were then constructed for the male and female categories of the cohort (see Figures 22 and 23).

Figure 22. Decomposition diagram showing strength of association between actions imagined to be performed by males during the evacuation of the Costa Concordia



The standardised route of actions imagined to be performed by males shown in Figure 22 is a-c-d-b. This route is ended by a dead-end at ‘Incorrect Interpretation’. The three transitions with greatest strength of association to base rate ratios are ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (mn, R = 21.29), ‘Receive Instructions’ to ‘Follow Instructions’ (hj, R = 10.70) and ‘Encounter Evacuation Problems’ to ‘End of Involvement’ (no, R = 10.40). These are the same as for the entire cohort. Immediately, this similarity may indicate there to be less variability in the imagined cohort with respect to those transitions considered important.

Figure 23. Decomposition diagram showing strength of association between actions imagined to be performed by females during the evacuation of the Costa Concordia



The standardised route of actions imagined to be performed by females shown in Figure 23 is a-b-d-b. This route is ended by a loop back to ‘Ambiguous Perception’. This is the same implied route as that of the entire cohort. The three transitions with greatest strength of association to base rate ratios are ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (mn, R = 15.42), ‘Receive Instructions’ to ‘Follow Instructions’ (hj, R = 7.74), and

‘Encounter Evacuation Problems’ to ‘End of Involvement’ (no, R = 7.53). These are the same as for males and for the entire cohort.

Further visual comparison of the decomposition diagrams suggests many more types of transitions for females. Figure 22 shows males to report 17 transitions with sufficient strength of association. For females, this becomes 24 transitions. Females reported many more strengths of association with actions involving ambiguous perceptions and incorrect interpretations, including after unambiguous perception had apparently occurred. These mixed perceptions then showed strengths of association with seeking travel companions and following others before reporting seeking information. Conversely, males showed a more balanced strength of association between ambiguous and unambiguous perception before the search for companions. Once instructions were received, the trajectories of each sub-cohort seemed similar.

5.4.2 Age

The complete cohort of 40 participants consisted of 26 participants under the age of 41 years old, 10 between the ages of 41 and 60, and 4 aged over 60 years. The frequencies of acts of each sub-cohort were recorded (see Table 13).

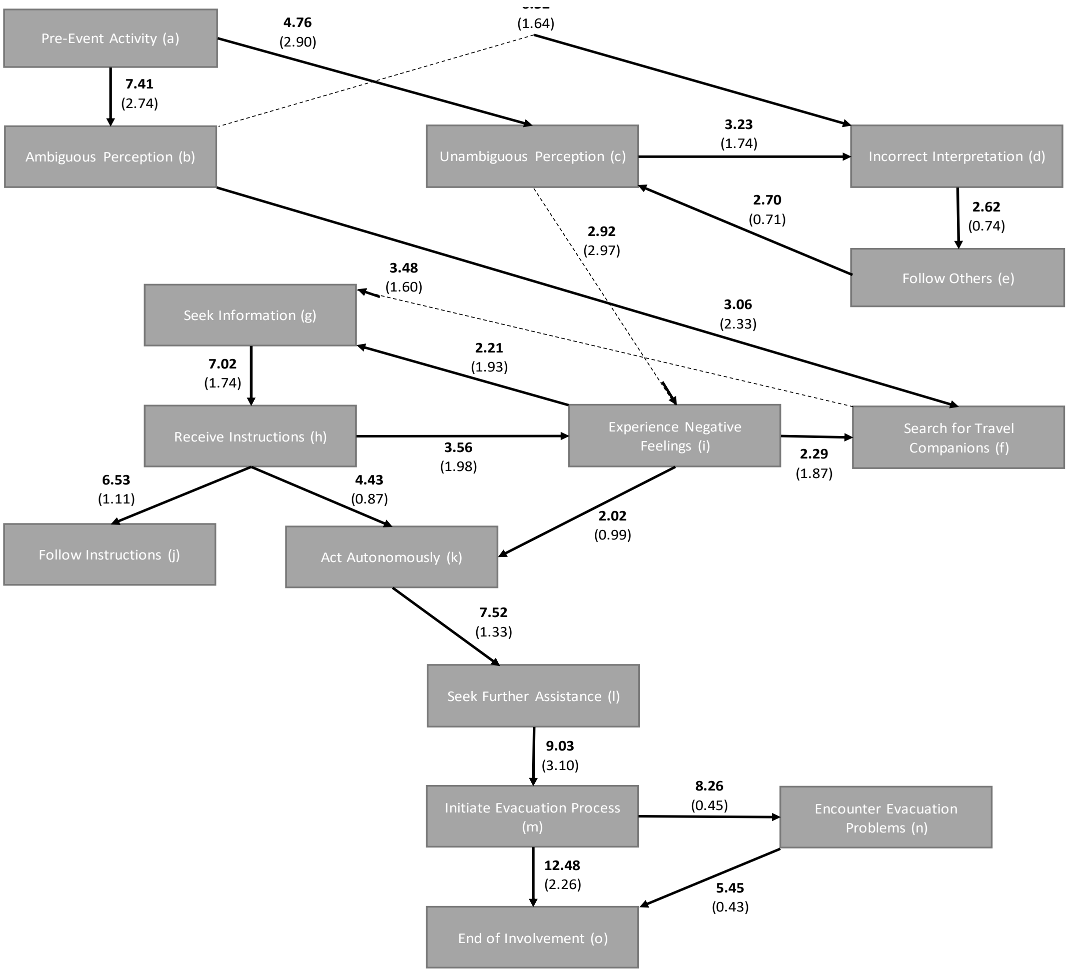
Table 13. Act frequency comparison between passengers by age group in imagined scenario

Act	< 41	41 - 60	> 60
Pre-Event Activity	26	10	4
Ambiguous Perception	30	12	9
Unambiguous Perception	33	12	9
Incorrect Interpretation	19	4	1
Follow others	12	7	4
Search for travel companions	21	10	3
Seek for information – Investigate	25	9	2
Receive Instructions	22	9	4
Experience Negative Feelings	31	10	0
Follow Instructions	11	9	3
Disregard Instructions – Act Autonomously	13	4	1
Seek further assistance	32	15	8
Initiate evacuation process – Board lifeboats	27	11	4
Encounter evacuation problems	6	2	0
End of Involvement – Abandon Ship	26	11	4

A Shapiro-Wilk test showed the frequency of acts for each sub-cohort to be normally distributed (<41: $W(13) = 0.933$, $p = .371$; 41to 60: $W(13) = 0.948$, $p = .561$; >60: $W(13) = 0.877$, $p = .064$). That the test showed the acts for those over 60 to be borderline was noted and further analysis proceeded with caution. Pearson correlation analysis was undertaken which showed significant correlations between the frequencies with which similar experiences were reported by each age group (‘<41 v 41-60’: $r(11) = .82$, $p < .001$; ‘<41 v

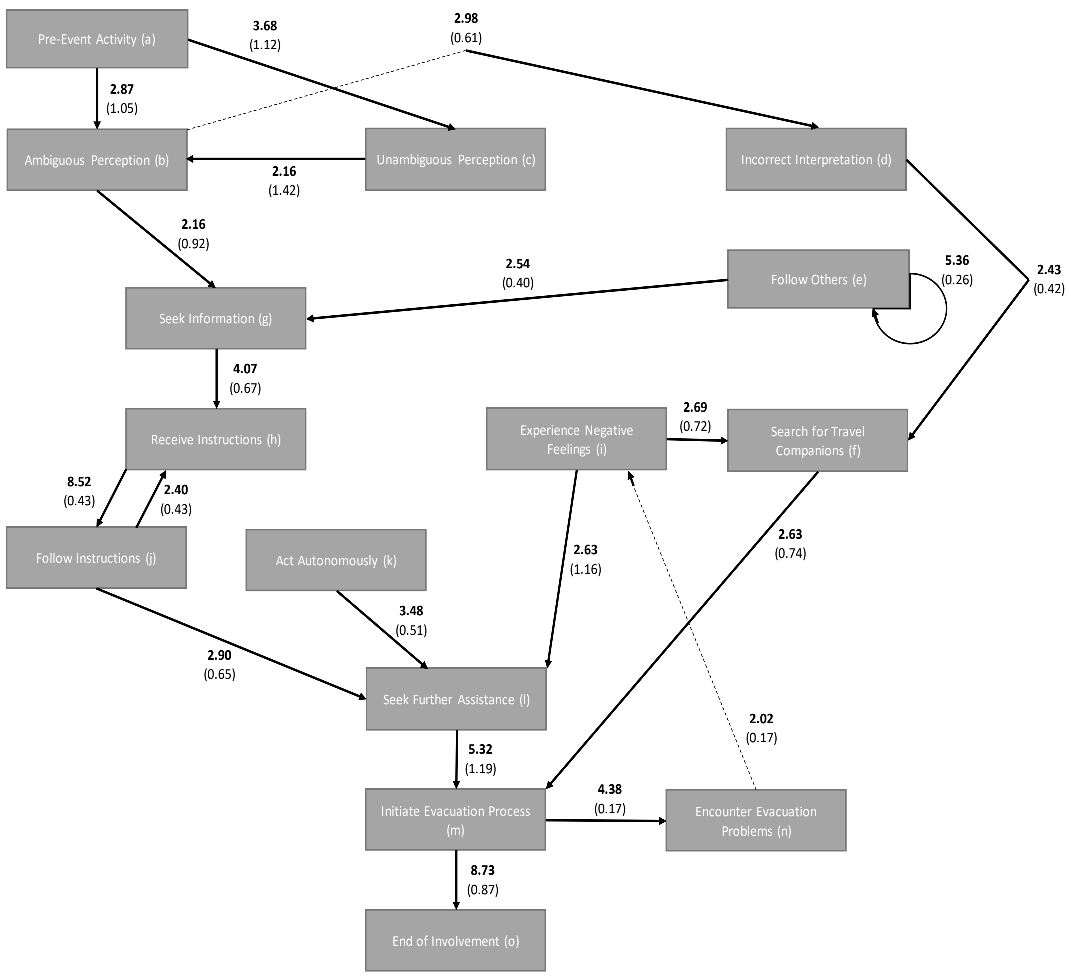
>60’: $r(11) = .60$, $p = .031$; 41-60 v >60: $r(11) = .76$, $p = .003$). Decomposition diagrams were then constructed for each sub-cohort (see Figures 24, 25 and 26).

Figure 24. Decomposition diagram showing strength of association between actions imagined to be performed by those aged under 41 during the evacuation of the Costa Concordia



The standardised route of actions imagined to be performed by participants under 41 shown in Figure 24 is a-b-d-e-c-d. This route is ended by a loop back to ‘Incorrect Interpretation’. Although truncated, this implied route is different to that of the entire cohort through the inclusion of the act ‘Follow Others’. The three transitions with greatest strength of association to base rate ratios are ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (mn, R = 18.36), ‘Encounter Evacuation Problems’ to ‘End of Involvement’ (no, R = 12.67), and ‘Receive Instructions’ to ‘Follow Instructions’ (hj, R = 5.88). These are the same as for the entire cohort, albeit with second and third place swapped.

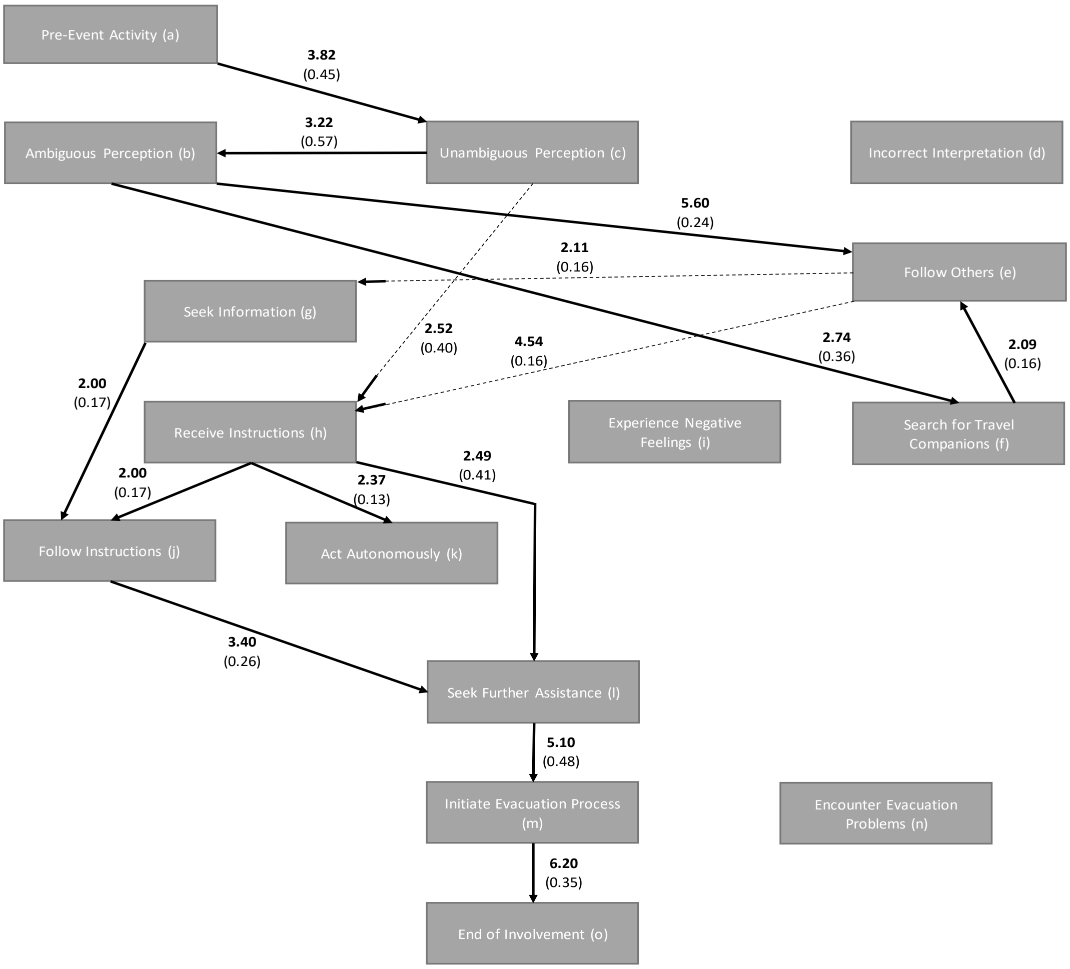
Figure 25. Decomposition diagram showing strength of association between actions imagined to be performed by those aged between 41 and 60 during the evacuation of the Costa Concordia



The standardised route of actions imagined to be performed by participants aged 41 - 60 shown in Figure 25 is a-c-b-d-f-m-o. This is a complete route through evacuation.

However, it seems not to be a logical route. After immediate ‘Unambiguous Perception’ there follows ‘Ambiguous Perception’ then ‘Incorrect Interpretation’. The route then indicates the act ‘Search for Travel Companions’ is sufficient to move to ‘Initiate Evacuation Process’. The route does not include the acts ‘Seek Information’, ‘Receive/Follow Instructions’ or even ‘Follow Others’. This may hint at a high sense of self-competence when imagining scenarios. The three transitions with greatest strength of association to base rate ratios are ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (mn, R = 18.36), ‘Encounter Evacuation Problems’ to ‘End of Involvement’ (no, R = 12.67), and ‘Receive Instructions’ to ‘Follow Instructions’ (hj, R = 5.88). These are the same as for the entire cohort, albeit with second and third place swapped.

Figure 26. Decomposition diagram showing strength of association between actions imagined to be performed by those aged over 60 during the evacuation of the Costa Concordia



The standardised route of actions imagined to be performed by participants over 60 shown in Figure 26 is a-c-b-e-h-l-m-o. This is a complete route through evacuation. The transition from ‘Ambiguous Perception’ following ‘Unambiguous Perception’ is interesting and may suggest that participants imagined perceiving ambiguous cues even once the threat had been established. This hint of extra caution is reinforced by the acts ‘Follow Others’ and ‘Seek Further Assistance’ being part of the implied route. The three transitions with greatest strength of association to base rate ratios are ‘Follow Others’ to ‘Receive Instructions’ (eh, R

= 28.38), ‘Ambiguous Perception’ to ‘Follow Others’ (be, R = 23.33), and ‘Receive Instructions’ to ‘Act Autonomously’ (hk, R = 18.23). These are markedly different to those of the entire cohort. The two most unexpectedly high transitions are centred on the act ‘Follow Others’. The third demonstrates a tendency to ‘Act Autonomously’ which may explain the appearance of ‘Seek Further Assistance’ in the implied route.

Although these results should perhaps be approached with a certain amount of caution due to differences in sub-cohort size, differences seem apparent. With increased age, the initial reported action seemed more unambiguous. Indeed, the eldest sub-cohort seemed to only show immediate strength of association with unambiguous perception. Conversely, the youngest sub-cohort seemed most likely to report a mistake in interpreting ambiguous cues. This occurred even after apparent unambiguous perception. Similarly, once there was an unambiguous perception, reports of negative feelings were most prevalent in the youngest sub-cohort and decreased with age. The search for travel companions seemed fairly constant over age ranges. The eldest sub-cohort reported a strong association with following others subsequent to ambiguous perception, which led them to receiving instructions. The middle sub-cohort seemed to repeatedly follow others before seeking information the youngest sub-cohort seemed most likely to act autonomously upon receiving instructions. Alternatively, the older cohorts seemed more likely to continually seek assistance and follow instructions.

5.4.3 Companions

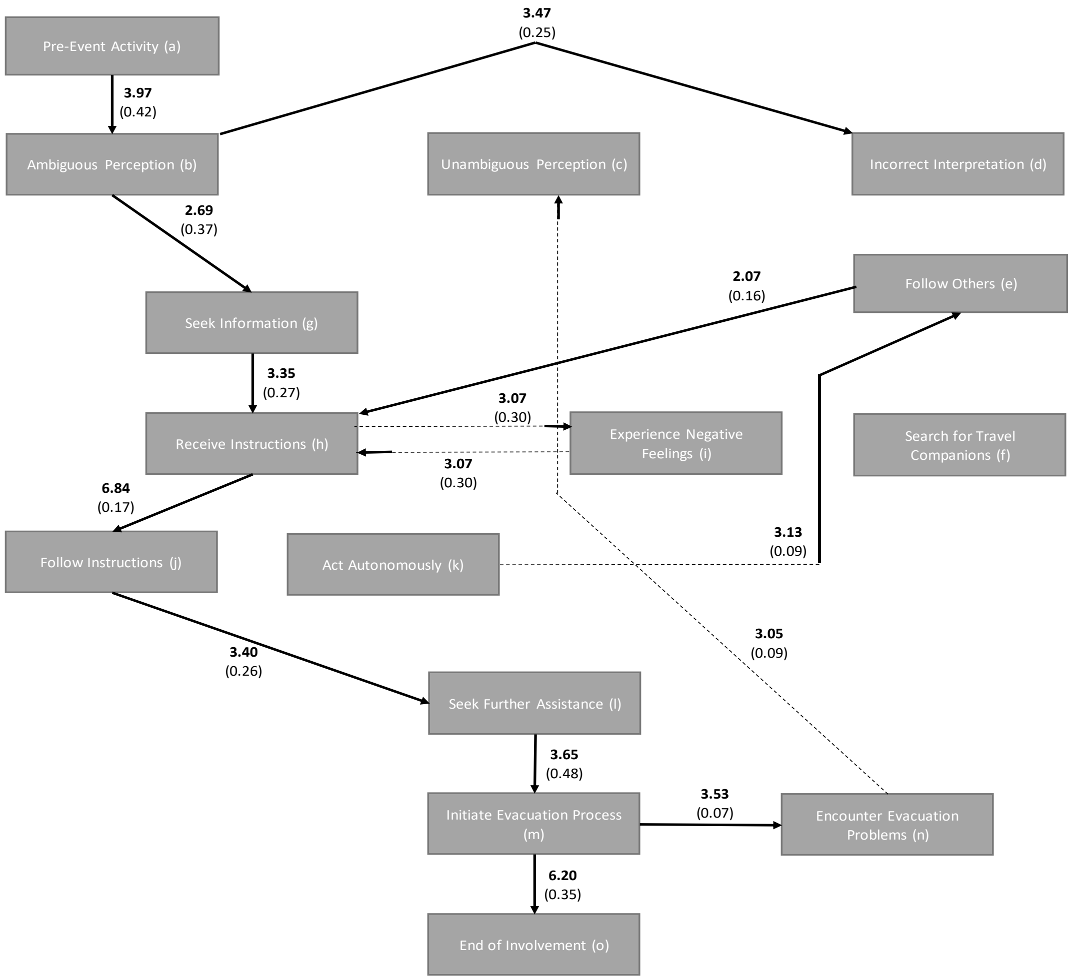
The complete cohort of 40 participants consisted of 4 participants who imagined themselves having travelled alone, 27 who travelled with others, and 9 who travelled with their children. The frequencies of acts of each sub-cohort were recorded (see Table 14).

Table 14. Frequency comparison between participants imagining themselves to be travelling alone, with others (friends, partners, family other than children) and with children

Act	Alone	Others	Children
Pre-Event Activity	4	27	9
Ambiguous Perception	6	34	11
Unambiguous Perception	6	37	10
Incorrect Interpretation	2	18	4
Follow others	2	18	3
Search for travel companions	0	24	9
Seek for information – Investigate	4	24	8
Receive Instructions	6	21	9
Experience Negative Feelings	4	28	9
Follow Instructions	3	14	6
Disregard Instructions – Act Autonomously	1	14	3
Seek further assistance	6	38	11
Initiate evacuation process – Board lifeboats	5	28	9
Encounter evacuation problems	1	6	1
End of Involvement – Abandon Ship	4	27	9

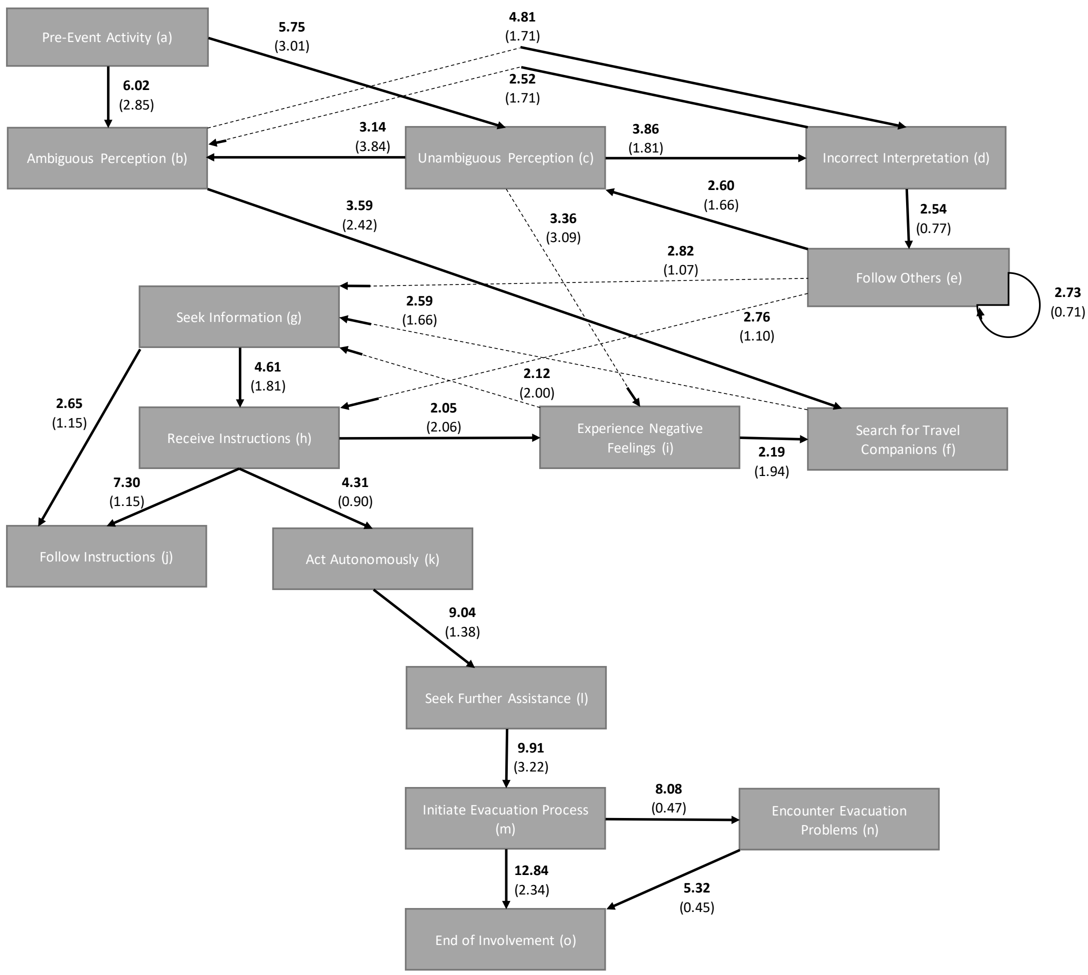
A Shapiro-Wilk test showed the frequency of acts for each sub-cohort to be normally distributed (Alone: $W(13) = 0.893$, $p = .108$; Others: $W(13) = 0.968$, $p = .868$; Children: $W(13) = 0.883$, $p = .078$). The test showed the acts for those who imagined themselves to have travelled with children was of borderline significance. Similarly, the number of participants in the 'Alone' and 'Children' sub-cohorts were relatively low. These issues were noted, and further analysis proceeded with caution. Pearson correlation analysis was undertaken which showed significant correlations between the frequencies with which similar experiences were reported by all sub-cohorts (Alone v Others: $r(11) = .74$, $p = .004$, Alone v Children: $r(11) = .75$, $p = .003$, Others v Children: $r(11) = .90$, $p < .001$). Decomposition diagrams were then constructed for each sub-cohort (see Figures 27, 28 and 29).

Figure 27. Decomposition diagram showing strength of association between actions taken by participants who imagined themselves to have travelled alone during the evacuation of the Costa Concordia



The standardised route of actions imagined to be performed by participants travelling alone shown in Figure 27 is a-b-d. This route is truncated by a dead-end at ‘Incorrect Interpretation’. The three transitions with greatest strength of association to base rate ratios are ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (mn, R = 50.43), ‘Receive Instructions’ to ‘Follow Instructions’ (hj, R = 40.24), and ‘Act Autonomously’ to ‘Follow Others’ (ke, R = 34.78). The top two transitions are similar to those of the entire cohort. The third transition suggests that those who travel alone are conscious of their 'aloneness' and seek guidance from those around them.

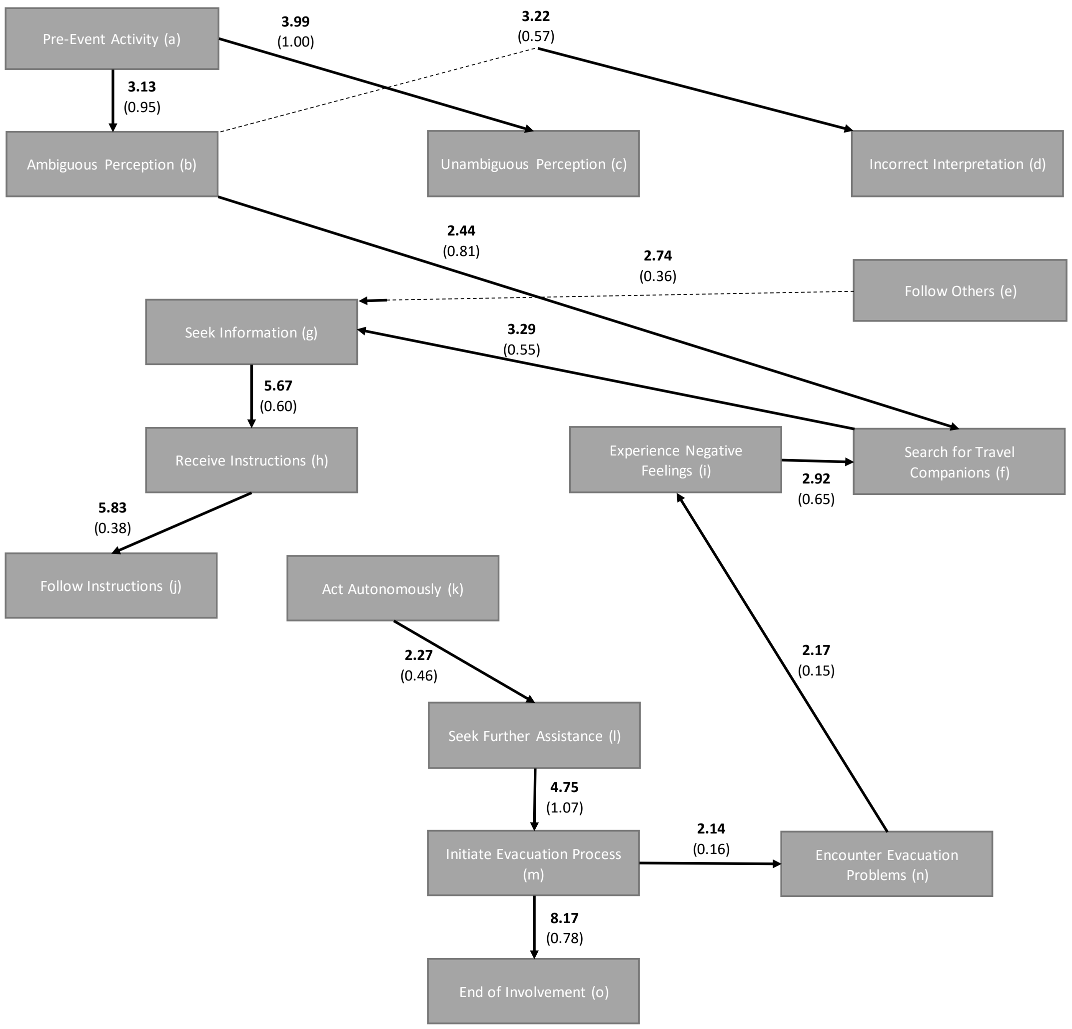
Figure 28. Decomposition diagram showing strength of association between actions taken by participants who imagined themselves to have travelled with others during the evacuation of the Costa Concordia



The standardised route of actions imagined to be performed by participants travelling with others shown in Figure 28 is a-b-d-e-g-h-j. This route is eventually truncated by a dead-end at 'Follow Instructions'. It seems to describe a logical route as far as it progresses. The three transitions with greatest strength of association to base rate ratios are 'Initiate

Evacuation Process' to 'Encounter Evacuation Problems' (mn, R = 17.15), 'Encounter Evacuation Problems' to 'End of Involvement' (no, R = 11.82), and 'Act Autonomously' to 'Seek Further Assistance' (kl, R = 6.55).

Figure 29. Decomposition diagram showing strength of association between actions taken by participants who imagined themselves to have travelled with children during the evacuation of the Costa Concordia



The standardised route of actions imagined to be performed by participants travelling with children shown in Figure 29 is a-c. This route is truncated by a dead-end at

‘Unambiguous Perception’. The three transitions with greatest strength of association to base rate ratios are ‘Receive Instructions’ to ‘Follow Instructions’ (hj, R = 15.34), ‘Encounter Evacuation Problems’ to ‘Experience Negative Feelings’ (ni, R = 14.47), and ‘Initiate Evacuation Process’ to ‘Encounter Evacuation Problems’ (mn, R = 13.38). Two of these are similar to the entire cohort. The third involves the ‘Experience Negative Feelings’ node which highlights the concerns parents may have if problems were encountered.

Those who imagined themselves to have travelled alone seemed to take the longest to attain unambiguous perception. The strongest association seems to occur once evacuation has become problematic. The other sub-cohorts tended to search for companions before seeking information. However, those travelling with children seemed to act more as a single unit reporting a more ordered route to evacuation. Those travelling with others showed more openness to acting autonomously, while those travelling alone seemed to follow others before receiving instructions. This may be due to the ‘others’ acting as a different source of information. These apparent differences should be viewed with caution due to the relative sizes of the sub-cohorts. However, what seems most apparent is that travelling with children produces a single unit, while travelling with others who are not children seems to promote interactions and transitions focused on those others.

5.4.5 Experience

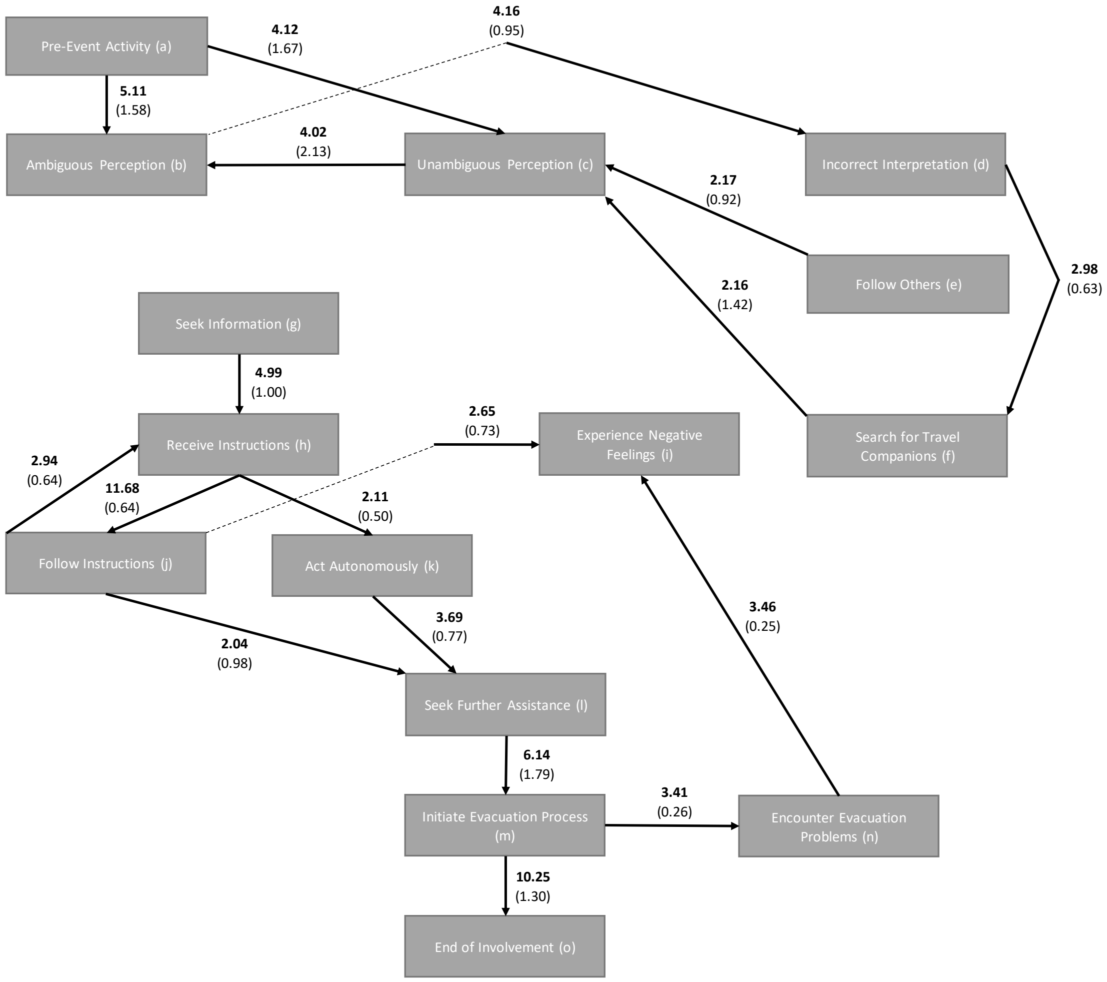
The complete cohort of 40 participants consisted of 15 participants who had previous experience travelling on a cruise ship, and 25 who did not. The frequencies of acts of each sub-cohort were recorded (see Table 15).

Table 15. Act frequency comparison between imagined passengers with previous experience on cruise ships and passengers with no previous experience

Act	Previous Experience	No Experience
Pre-Event Activity	15	25
Ambiguous Perception	20	31
Unambiguous Perception	20	34
Incorrect Interpretation	8	16
Follow others	7	15
Search for travel companions	12	22
Seek for information – Investigate	11	25
Receive Instructions	16	20
Experience Negative Feelings	15	26
Follow Instructions	12	11
Disregard Instructions – Act Autonomously	6	12
Seek further assistance	18	37
Initiate evacuation process – Board lifeboats	15	27
Encounter evacuation problems	2	6
End of Involvement – Abandon Ship	15	25

A Shapiro-Wilk test showed the frequency of acts for each sub-cohort to be normally distributed (Experience: $W(13) = 0.959$, $p = .741$; No Experience: $W(13) = 0.977$, $p = .964$). Pearson correlation analysis was undertaken which showed a significant correlation between the frequencies with which similar experiences were reported by each experience group ($r(11) = .88$, $p < .001$). Decomposition diagrams were then constructed for each sub-cohort (see Figures 30 and 31).

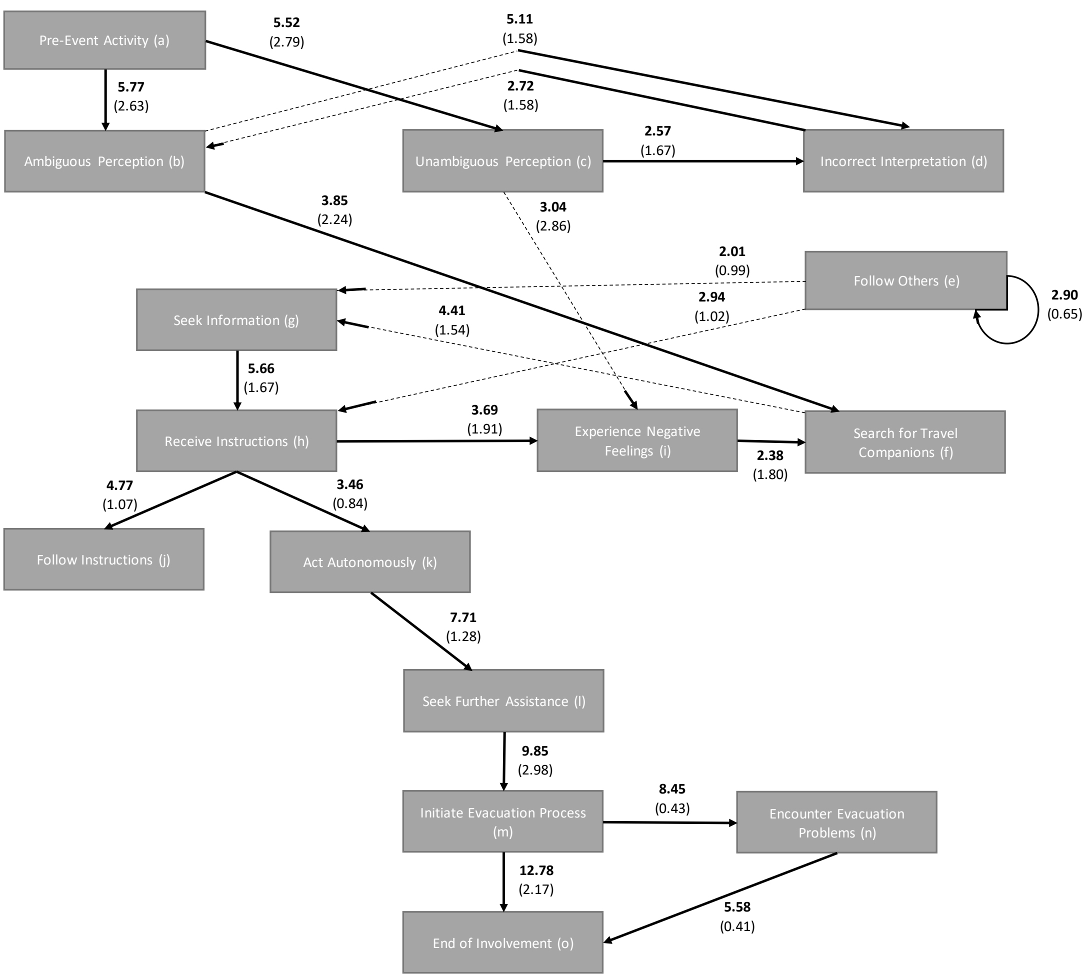
Figure 30. Decomposition diagram showing strength of association between actions taken by participants with previous cruise ship experience imagining the evacuation of the Costa Concordia



The standardised route (going from 'Pre-Event Activity' based on the greatest strength of association until either 'End of Involvement' or an act) of actions imagined to be performed by participants with previous cruise ship experience shown in Figure 30 is a-b-d-f-c-b. This route is truncated by a loop back to 'Ambiguous Perception'. The three transitions with greatest strength of association to base rate ratios are 'Receive Instructions' to 'Follow Instructions' (hj, R = 18.25), 'Encounter Evacuation Problems' to 'Experience Negative

Feelings' (ni, R = 13.84), and 'Initiate Evacuation Process' to 'Encounter Evacuation Problems' (mn, R = 13.12). Two of these are similar to the entire cohort.

Figure 31. Decomposition diagram showing strength of association between actions taken by participants without previous cruise ship experience imagining the evacuation of the Costa Concordia



The standardised route of actions imagined to be performed by participants without previous cruise ship experience shown in Figure 31 is a-b-d-b. This route is truncated by a loop back to 'Ambiguous Perception'. The three transitions with greatest strength of association to base rate ratios are 'Initiate Evacuation Process' to 'Encounter Evacuation Problems' (mn, R = 19.65), 'Encounter Evacuation Problems' to 'End of Involvement' (no, R = 13.61), and 'Act Autonomously' to 'Seek Further Assistance' (kl, R = 6.02).

The trajectories of each sub-cohort seem very similar. One difference is that those with previous experience seemed to perform social actions before attaining unambiguous perception. Conversely, following others and seeking travel companions seemed to drive those without previous experience. Also, perhaps surprisingly, it was the sub-cohort with previous experience who showed a greater strength of association for following instructions as opposed to acting autonomously. It is during these later stages that those with experience report the state of their emotions. Those without experience strongly associate the unambiguous perception and receiving instructions with heightened feelings. Finally, as expected, it was the sub-cohort with no experience who encountered evacuation problems.

5.4.6 Summary of Study 2

Unlike the results of the real-life cohort (see section 4.3.5, Table 9), the entire imagined cohort does not provide a complete implied route through evacuation (see Table 16). Again, two of the ten sub-cohorts displayed a complete navigation through the evacuation. However, neither the routes nor the sub-cohorts were the same.

Table 16. Summary of implied routes and important transitions visible in Study 2 decomposition diagrams (Figures 22 to 31)

Cohort	Sub-cohort	Implied Route	Important Transitions		
			1st	2nd	3rd
All	-	a-b-d-b	mn	hj	no
Gender	Male	a-c-d-b	mn	hj	no
	Female	a-b-d-b	mn	hj	no
Age	<41	a-b-d-e-c-d	mn	no	hj
	41 to 60	a-c-b-d-f-m-o	mn	no	hj
	>60	a-c-b-e-h-l-m-o	eh	be	hk
Companions	Alone	a-b-d	mn	hj	ke
	Others	a-b-d-e-g-h-j	mn	no	kl
	Children	a-c	hj	ni	mn
Experience	Previous	a-b-d-f-c-b	hj	ni	mn
	None	a-b-d-b	mn	no	kl

It is interesting to note that in the imagined condition, males and females seem to have reported comparable accounts. With respect to cohorts of different age groups, it is interesting to see that older groups showed the complete navigations while the youngest cohort repeated incorrect interpretations. Overall, it seems the accounts of the entire cohort, demonstrating a tendency to loop around incorrect interpretations, is visible in each sub-cohort.

With respect to the most important transitions, those demonstrated by the imagined cohort were similar to those shown by the real-life cohort. Indeed, each of the sub-cohorts seemed to demonstrate the same important transitions. Of the thirty transitions of the sub-cohorts, twenty-two were one of the three noted against the entire cohort. It was only the sub-cohort aged over sixty, which did not share an important transition with those of the entire cohort. This may hint at a lack of ecological validity of the talk-through method. However, the lower variability of imagined accounts points to the consistency of reports already shown to be collectively similar to real-life accounts. This would suggest that, in further research utilizing more structured and controlled experimental research, any differences discovered by systematic manipulations of factors would be due to those manipulations.

Transition 'mn', 'Initiate Evacuation Process' to 'Encounter Evacuation Problems', is again consistently visible in results. It is the most important transition in both the entire cohort and seven of the ten sub-cohorts. Similar to the real-life cohort, it does not appear in a single implied route. The second most important transition in the entire cohort, hj, is the most important in two of the three remaining sub-cohorts. Yet, this transition only appears in a single implied route. It is the over 60 sub-cohort which seems to stand apart from all others.

5.5 Study 2 - Discussion

5.5.1 Comparison of Real-Life v Imagined Results

Significant correlation between accounts produced by the participants imagining actions and the real-life accounts of the evacuation of the Costa Concordia were reported. Similarly, breaking down the entire cohort into multiple categories continued to demonstrate significant correlations between accounts in terms of acts reported. Finally, the accounts of acts of all sub-cohorts demonstrated normal distribution, albeit with a few demonstrating borderline test statistics. These are encouraging statistics; however, they do not paint a complete picture. Analysis of the decomposition diagrams highlights variability in the acts and transitions between acts reported by the various sub-cohorts.

The method of data collection involved in this study consisted of the coding of accounts provided by participants imagining themselves to be evacuating a ship similar to the Costa Concordia. These accounts were recorded in a lab-setting and guided by the researcher. This differs from the original method in that original real-life accounts were pre-recorded in a trial-setting guided by legal professionals. The aim of this study was to gauge whether the talk-through method (Lawson, 2011) is capable of providing similar data to real-life accounts. If so, this then becomes a valuable tool in the collection of reliable data for examination in relation to evacuation procedures in multiple possible scenarios. This is very important because, as stated above, investigation needs to progress from standard initial qualitative investigation of events towards methods which enable accurate quantitative evaluation (Lawson et al., 2013). This is particularly true if the final goal is to provide a complete model integrating computational and behavioural models.

Statistically significant correlations indicated the granularity and detail of descriptions provided by imagined accounts to be similar to those provided by real-life accounts. It also implies the report of numbers of each type of act to be comparable. However, visual examination of the decomposition diagram for the cohort immediately portrays a more varied course of events (see Figure 21). Of initial concern is that the defined chain of initial events visible in the real-life cohort was not replicated. This is especially concerning as it seems to reject the assumption of demonstrated face validity apparent in said chain of events. It seems those who imagine themselves to be in such a scenario do not report a strong, statistically demonstrable tendency to perform certain acts during the 'dawning of realisation'. This would perhaps imply some kind of imaginative suppression due to the lab-setting of the interview. Equally, this could be an artefact of the differences in data collection. As has been discussed, negative feelings result in the loss of peripheral details and the increased focus on central details (Talarico et al., 2009). The absence of heightened emotions may promote greater description of these peripheral details. This explanation is further evidenced by the finding that those in the imagined scenario were not significantly quicker to achieve 'Unambiguous Perception'. It can be reasonably assumed that those participants imagining events are aware of the purpose of their imaginings. They are aware they are on a ship and the first 'Ambiguous Perception' should be enlightening as to the purpose of the interview. Taken in conjunction, these unexpected findings highlight an extended issue to the different settings of account extraction. It is already understood that an imagined account produced in a lab setting will not be affected by high emotion in the same way a real-life account may be. However, it seems the purpose of the account may also be different. Real-life accounts were gathered by legal professionals guided towards establishing a line of events ultimately to judge liability. In a lab setting, guided by a researcher, themselves attempting to not bias the participants' responses, the true purpose of the account may not be realised. Instead of trying to create a clear, accurate timeline of actions undertaken, the participant may be attempting to create a context-rich version of events, portraying themselves in the best light, and ultimately aiming to tell the researcher what they think the researcher wants to hear.

The role of such demand characteristics is perhaps visible in the initial coding differences between real-life and imagined cohorts. It is immediately apparent from visual analysis of the decomposition diagram of the entire cohort that there is a greater reporting of social acts. During initial analysis, it was noted that the real-life act 'Stay in Position' seemed to have been replaced by the social act 'Follow Others' in the imagined accounts. This is somewhat mirrored by the tendency in the imagined cohort to 'Search for Travel Companions' upon first attaining 'Ambiguous Perception'. Though perhaps not peripheral, these describe goals separate to timely evacuation (Proulx, 1995). Participants may have been attempting to portray themselves as altruists or may have been under the mistaken assumption that the present study was concerned with crowd behaviour. Ultimately, it may simply be a comforting imaginative heuristic or bias that, if one found oneself in a potentially life-threatening emergency scenario, one would be surrounded by informed, capable, and dependable others (Finucane et al., 2000). Whatever the explanation, this potential issue must be flagged as a potentially over-arching issue with the talk-through method. That the detail of accounts is similar does not necessarily mean the objective of accounts is similarly directed. Correlation does not explain causation.

5.5.2 Study 2 - Trait Analysis

Initial analysis showed all categorisations of sub-cohorts showed strong correlations. This is a slight concern as it does not reflect the non-correlative nature of the reports of those who travelled alone in the real-life cohort. However, both such sub-cohorts in each condition consisted of relatively few members, so the explanations for differences or lack thereof may be numerical rather than statistical. Behavioural sequence analysis and the resultant decomposition diagrams painted a similar picture to that portrayed in the decomposition diagram of the complete cohort. Yet even though there still appeared to be greater variability in acts, especially with regards to those socially focused acts, certain key differences were replicated. As in the real-life cohort, females reported many types of actions before ‘Unambiguous Perception’. It has previously been noted that females show a tendency to show perception to cues and perform pro-social acts in evacuation scenarios (Kuligowski, 2009; Wood, 1980). Similarly, it still seemed apparent that with greater age comes a greater tendency to follow instructions. There is little in the literature about following instructions, only youth as an advantage in speed of evacuation could be found (Wood, 1980). Travelling with children led to different actions in comparison to travelling with others. This may link to findings that groups already familiar with each other showed more efficient allocation of resources (Aguirre et al., 2011). However, experience leading to more immediate 'Unambiguous Perception' was not visible. Again, this may be explained by differences in perceived purpose of storytelling style between conditions.

5.5.3. Overview of the Results of Study 2

Analysis of results obtained by the talk-through method revealed interesting similarities and differences. There seemed to be very little overall difference between males and females, whereas the over-sixty sub cohort were very different to other sub-cohorts and the cohort as a whole. This may hint at different imaginative or storytelling processes in older people. The cohort as a whole did not clearly display the strengths of association of the real-life cohort. Similarly, when broken down into categorised sub-cohorts, the variability produced by imagined accounts, though somewhat reduced, was still clearly visible. However, one of the over-arching purposes of the trait analysis in the present study is to uncover fundamental similarities in the data produced by each method of data collection, as a test of validity. An important similarity for current purposes is that certain trait-based differences were still detectable in the imagined cohort.

Chapter Six: A Comparison of ‘Real-Life’ v ‘Imagined’ Accounts

6.1 Introduction

In order to accelerate the production of reliable data concerning maritime evacuation, imagined accounts need to mirror real-life accounts. This must be true at a more than preliminary level. If contradictions are uncovered by further scrutiny, it would seem sensible to redirect methods towards a more effective process for evacuation research. It is predicted that correlation analysis will portray statistically significant similarities between the data. However, with deeper examination, these similarities will dissolve. Ultimately, it is anticipated that the development of a new approach is required to allow for more effective data collection and analysis. In turn, this will lead to more persuasive evidence for implementation into maritime safety procedures and protocols.

6.2 Method of Analysis

The acts recorded for the ‘real-life’ and ‘imagined’ studies were converted into percentages of total acts within each study. This enabled cross-study statistical analysis (see Table 17).

Table 17. Act frequencies as percentages for comparison between passengers in real-life versus imagined scenario

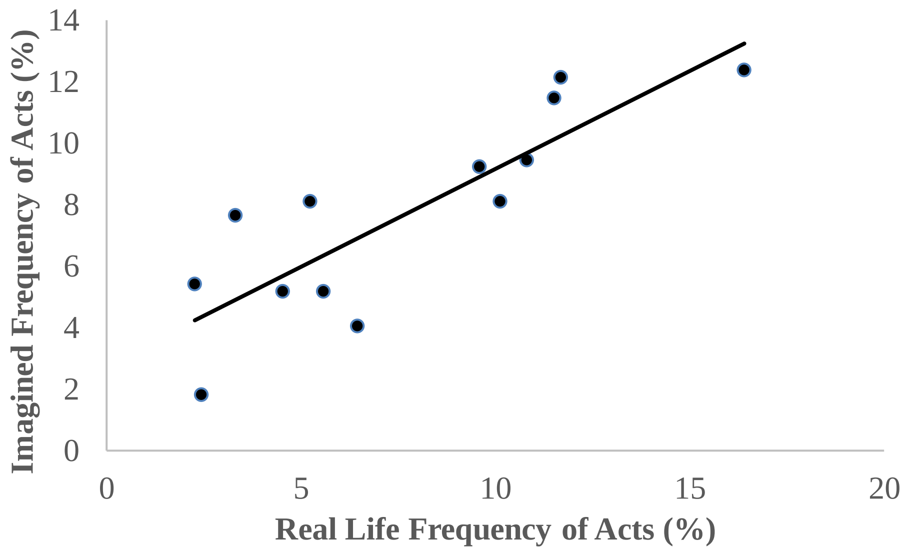
		Frequencies	(as % of total acts)
Code	Act	Real-life	Imagined
a	Pre-Event Activity	11.52	11.46
b	Ambiguous Perception	11.69	12.13
c	Unambiguous Perception	2.27	5.39
d	Incorrect Interpretation	4.54	5.17
e	Follow others	3.32	7.64
f	Search for travel companions	5.24	8.09
g	Seek information	10.12	8.09
h	Receive instructions	9.60	9.21
i	Experience negative feeling	5.58	5.17
j	Follow instructions	6.46	4.04
k	Act Autonomously	16.40	12.36
l	Seek further assistance	10.82	9.44
m	Initiate evacuation process	2.44	1.80
n	Encounter evacuation process	11.52	11.46
o	End of involvement	11.69	12.13
	Total number of acts	573	445

6.3 Results

As before, the first and final acts were ignored due to their potential undue influence on analysis. Shapiro-Wilk analysis was undertaken. Each set of data was shown to be normally distributed, (Real-Life: $W(13) = 0.933$, $p = 0.37$, Imagined: $W(13) = 0.956$, $p = 0.69$).

Consequently, a Spearman correlation was undertaken which showed there to be a significant relationship between the reporting of acts ($r(11) = .844$, $p < .001$) (see Figure 32).

Figure 32. Scatterplot of comparison of frequencies as percentages of all reported actions between real-life and imagined scenarios

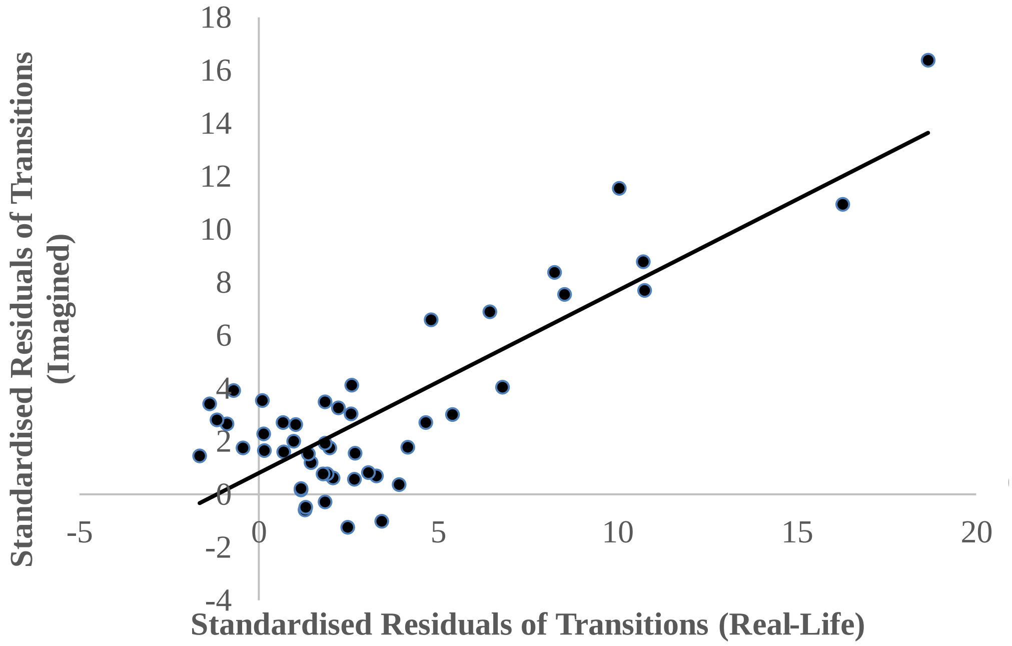


Visual inspection of the plotted points in Figure 32 support the finding of normal distribution. As no significant clustering or outliers were detected, analysis continued as planned.

A transition matrix was created for each scenario. Standardised residuals were calculated for each transition as observed frequency minus expected frequency divided by the square root of the expected frequency. The expected frequency was calculated as the sum of the row of transitions from a certain act multiplied by the sum of the column of transitions to that certain act, all divided by the grand total of transitions. As the transition matrix was constructed from the same taxonomy for each scenario, the number of different possible transitions was the same. Acts ‘a’ and ‘o’ were beginning and end points, so could each only be transitioned to or from a single time. Thus, the total number of possible different transitions was 196. In the real-life scenario, 101 of these possible transitions were reported, whereas in the imagined 97 were reported. There was a total of 81 transitions reported in both scenarios. However, prior to data cleansing, it was noted that certain transitions unreported in one scenario showed strength of association in the other. Thus, it was decided to compare all transitions with a standardized residual greater than 1. If such a residual was unreported in a scenario, the base rate was used for comparison. This resulted in 49 pairs of transitions for comparison.

A Shapiro Wilk test showed the standardized residuals of each scenario to be not normally distributed (Real-Life: $W(49) = 0.812$, $p < .001$, Imagined: $W(49) = 0.832$, $p < .001$). Consequently, a Spearman's rho test was conducted which showed a significant correlation between the ranking of reported transitions in real-life v imagined accounts of the same scenario ($r(47) = .373$, $p < .008$). (See Figure 33). Visual inspection of the scatterplot supports the statistical finding of non-normality. The majority of data points are clustered around '0'. This would imply the statistically significant correlation, and line of best fit, are due to the minority of data points further from the '0' point.

Figure 33. Scatterplot of comparison of standardized residuals of reported actions between real-life and imagined scenarios



The comparison of this collection of transitions was shown to be statistically significant. This would suggest the counts of transitions of sufficient strength were similar in each condition. However, the non-normality of the collection of data coupled with the clustering around '0' displayed in Figure 33 suggested further analysis was required to establish any precise roots of similarity. Therefore, it was decided to compare standardized residuals for those transitions showing strengths of association greater than '2' as depicted in the decomposition diagrams for the entire cohorts in each condition (see Figures 7 and 21). This resulted in a comparison of 34 transitions (see Figure 34).

Figure 34. Chart showing comparison of standardized residuals of reported actions between complete cohorts in real-life and imagined scenarios

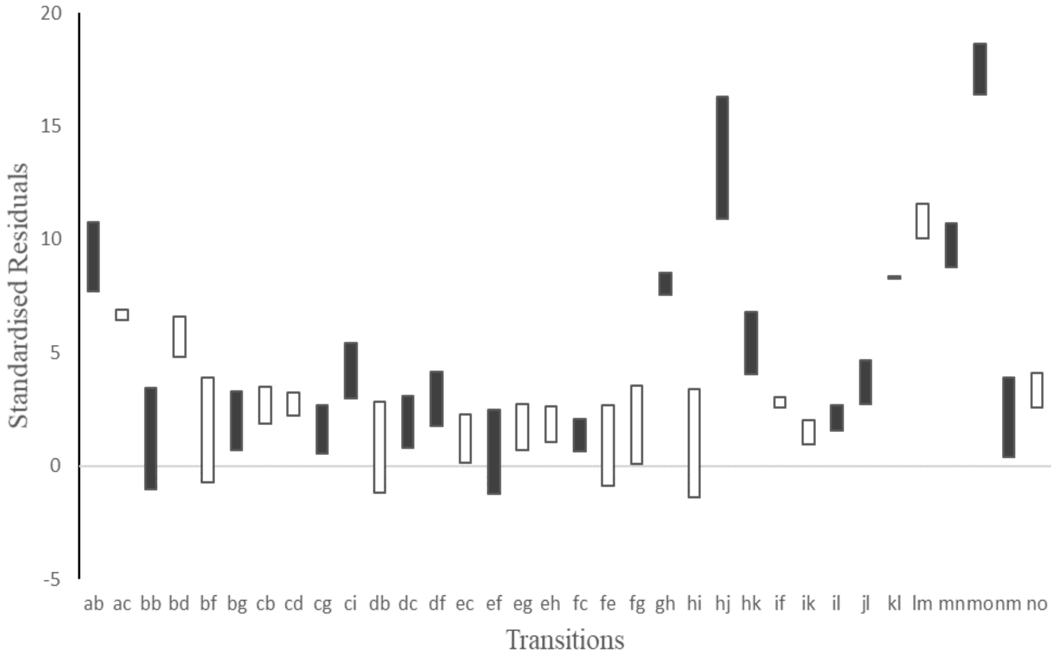
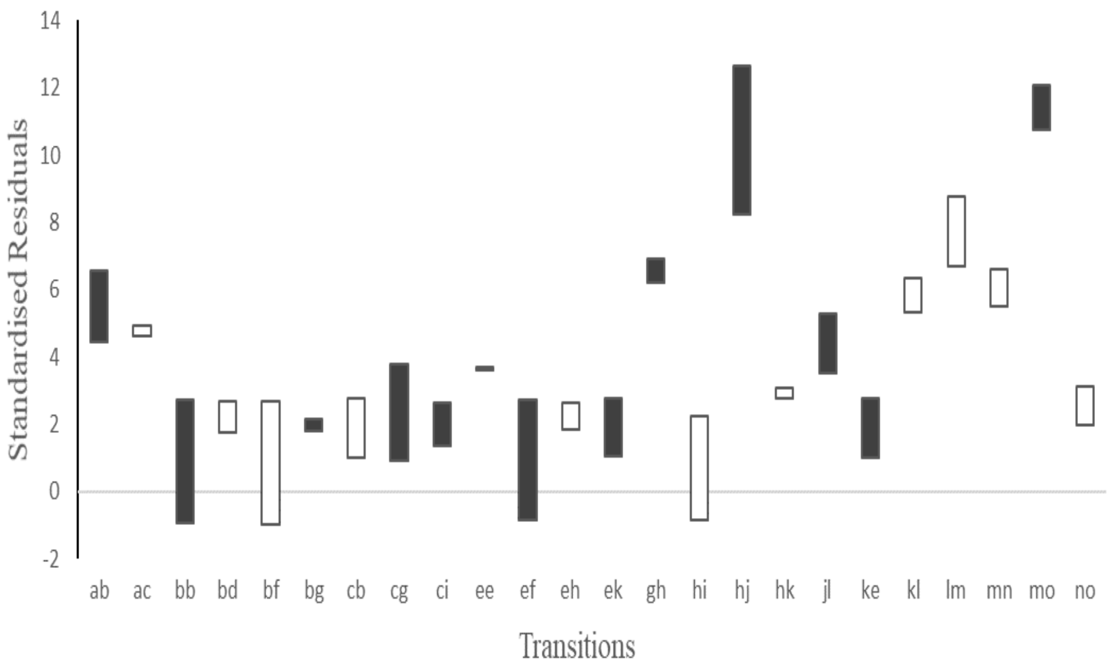


Figure 34 shows there to be much apparent variability in the transitions between reported acts in each scenario. White bars indicate the transition to be reported with greater strength of association in the imagined scenario, black bars if real-life scenario was greater. Ideally, each bar would be relatively small moderated by the size of the standard residual. Additionally, great variability can be deduced from those indicating negative standard residuals. These bars arise from zero or minimal transitions in either scenario.

In total, only fifteen of the thirty-four transitions were of a strength of association of greater than ‘2’ in both conditions. This finding again demonstrates how a statistically significant similarity obtained through correlation analysis may be misleading due to its collective nature. It seems the similarities between conditions are a result of less than half of the relevant transitions. It can also be seen that six transitions demonstrated a negative strength of association in either condition.

Due to this apparent wide variability, the transitions of each sub-cohort (gender, age, companions, previous experience) were similarly compared to the corresponding sub-cohort in each scenario (see Figures 35 to 44).

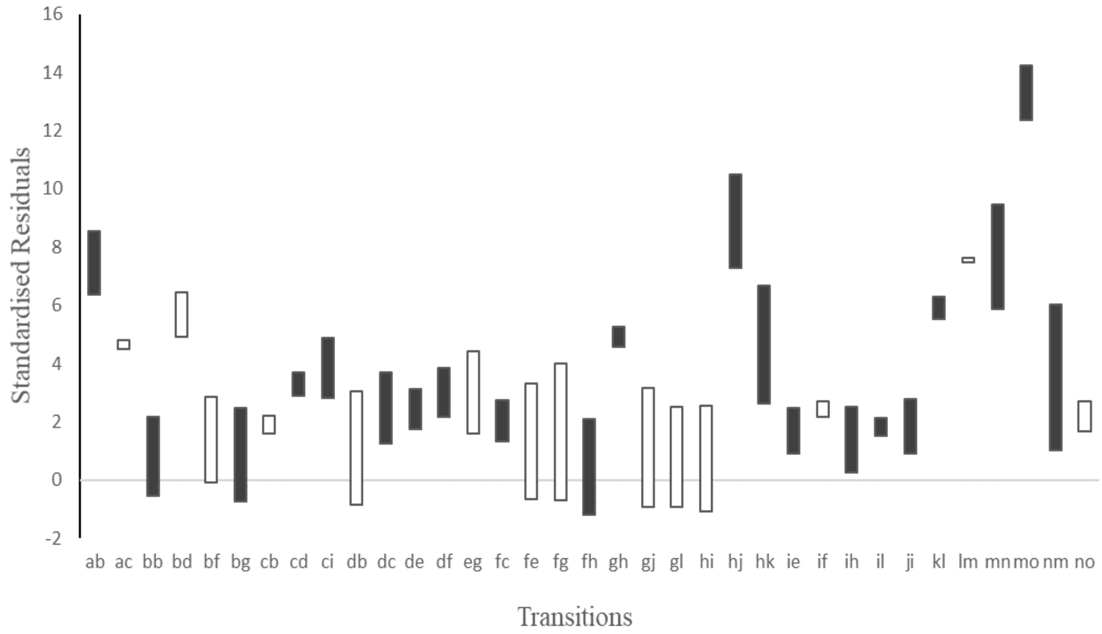
Figure 35. Chart showing comparison of standardized residuals of reported actions between male sub-cohorts in real-life and imagined scenarios



Note: White bars indicate the transition to be reported with greater strength of association in the imagined scenario, black bars if real-life scenario was greater.

Figure 35 shows only 11 of the 24 transitions were of sufficient strength of association in both conditions. Additionally, there were four transitions which contained a negative strength of association in either condition.

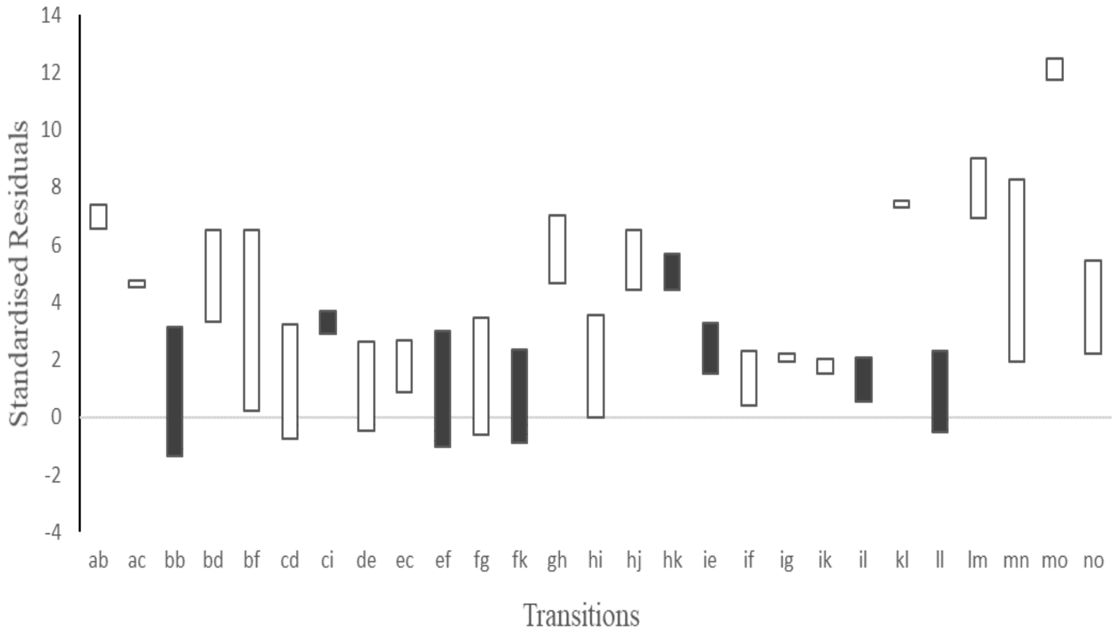
Figure 36. Chart showing comparison of standardized residuals of reported actions between female sub-cohorts in real-life and imagined scenarios



Note: White bars indicate the transition to be reported with greater strength of association in the imagined scenario, black bars if real-life scenario was greater.

Figure 36 shows only 14 of the 35 transitions were of sufficient strength of association in both conditions. Additionally, there were ten transitions which contained a negative strength of association in either condition.

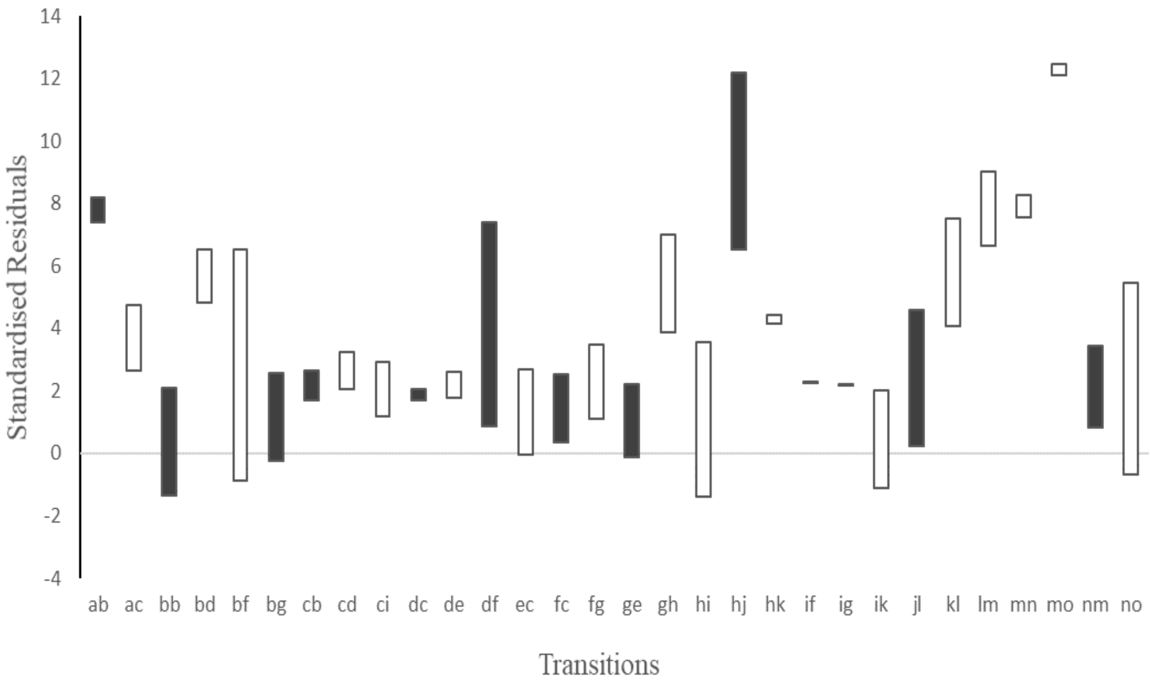
Figure 37. Chart showing comparison of standardized residuals of reported actions between participants aged below 41 sub-cohorts in real-life and imagined scenarios



Note: White bars indicate the transition to be reported with greater strength of association in the imagined scenario, black bars if real-life scenario was greater.

Figure 37 shows only 11 of the 27 transitions were of sufficient strength of association in both conditions. Additionally, there were eight transitions that contained a negative strength of association in either condition.

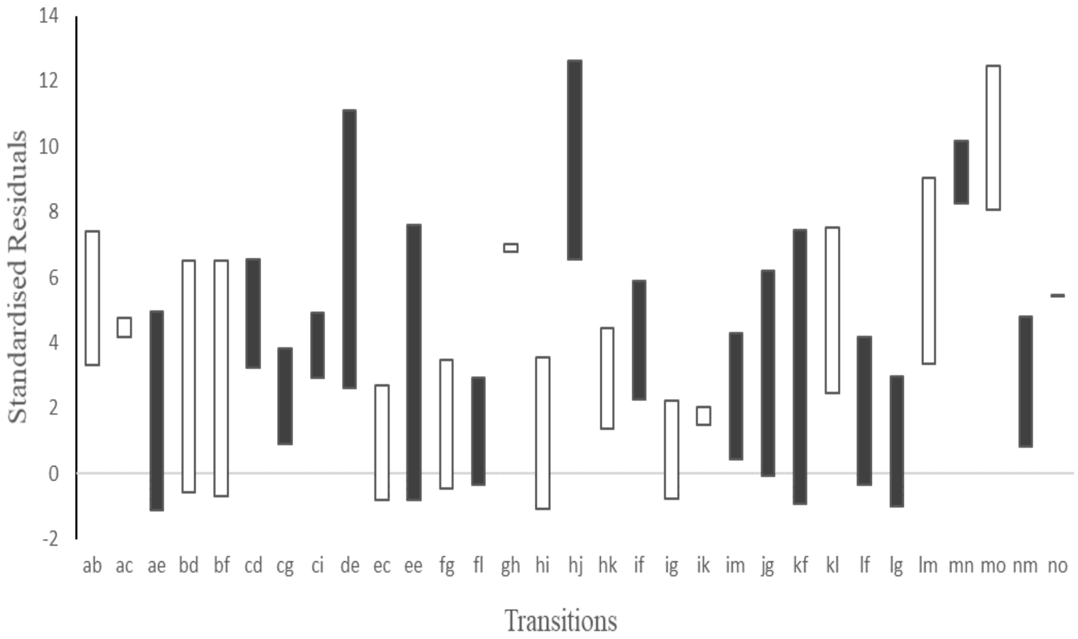
Figure 38. Chart showing comparison of standardized residuals of reported actions between participants aged between 41and 60 sub-cohorts in real-life and imagined scenarios



Note: White bars indicate the transition to be reported with greater strength of association in the imagined scenario, black bars if real-life scenario was greater.

Figure 38 shows only 13 of the 30 transitions were of sufficient strength of association in both conditions. Additionally, there were eight transitions which contained a negative strength of association in either condition.

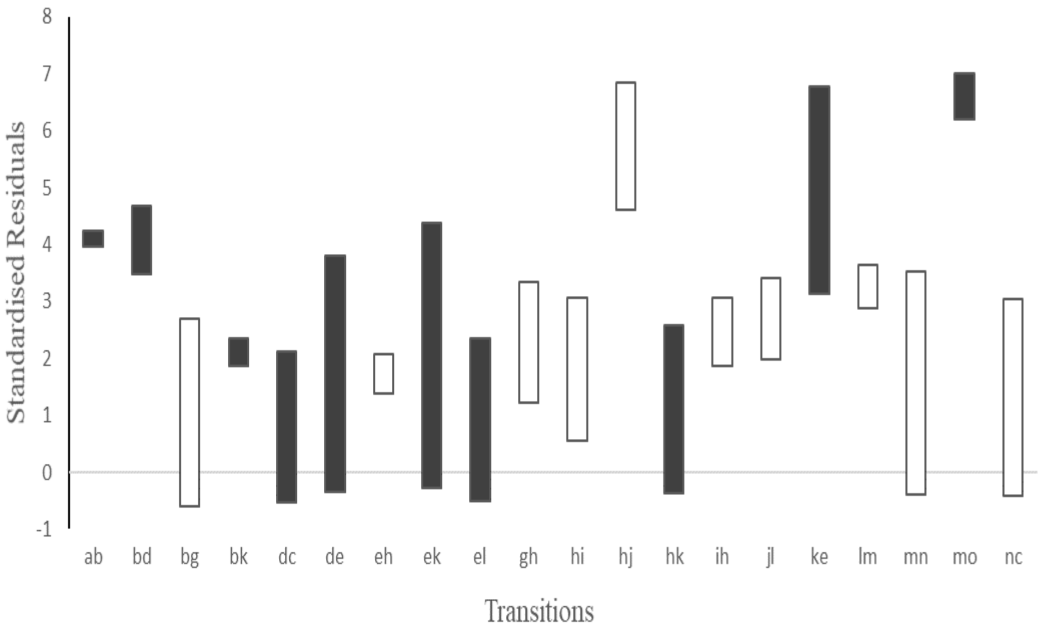
Figure 39. Chart showing comparison of standardized residuals of reported actions between participants aged over 60 sub-cohorts in real-life and imagined scenarios



Note: White bars indicate the transition to be reported with greater strength of association in the imagined scenario, black bars if real-life scenario was greater.

Figure 39 shows only 13 of the 31 transitions were of sufficient strength of association in both conditions. Additionally, there were thirteen transitions that contained a negative strength of association in either condition.

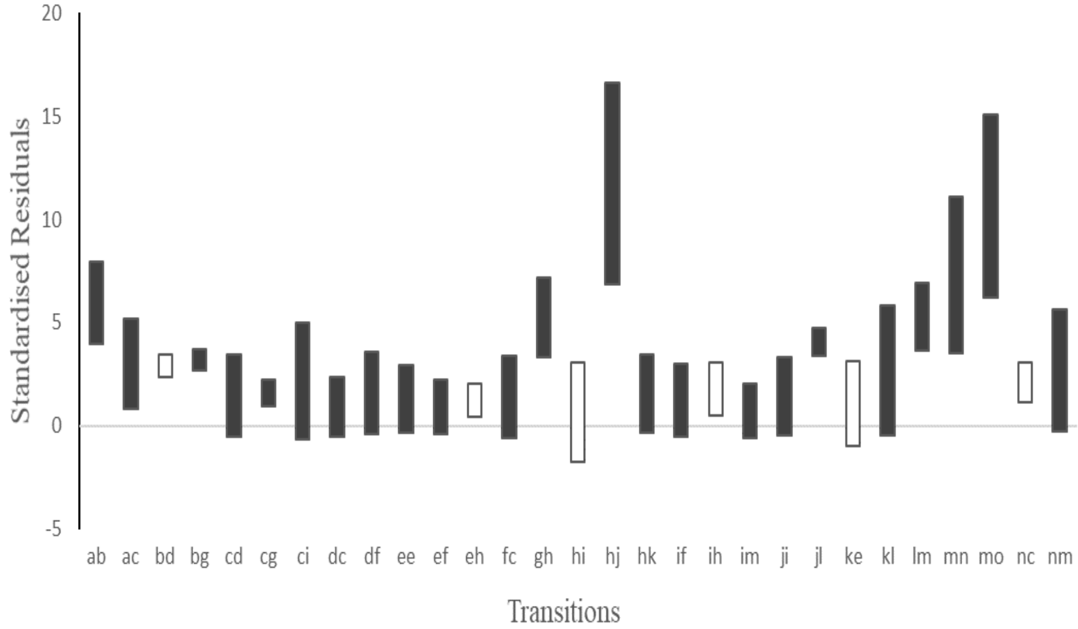
Figure 40. Chart showing comparison of standardized residuals of reported actions between those who travelled alone sub-cohorts in real-life and imagined scenarios



Note: White bars indicate the transition to be reported with greater strength of association in the imagined scenario, black bars if real-life scenario was greater.

Figure 40 shows only 6 of the 20 transitions were of sufficient strength of association in both conditions. Additionally, there were eight transitions that contained a negative strength of association in either condition. Indeed, there are more transitions with negative values than are of similar sufficient strength.

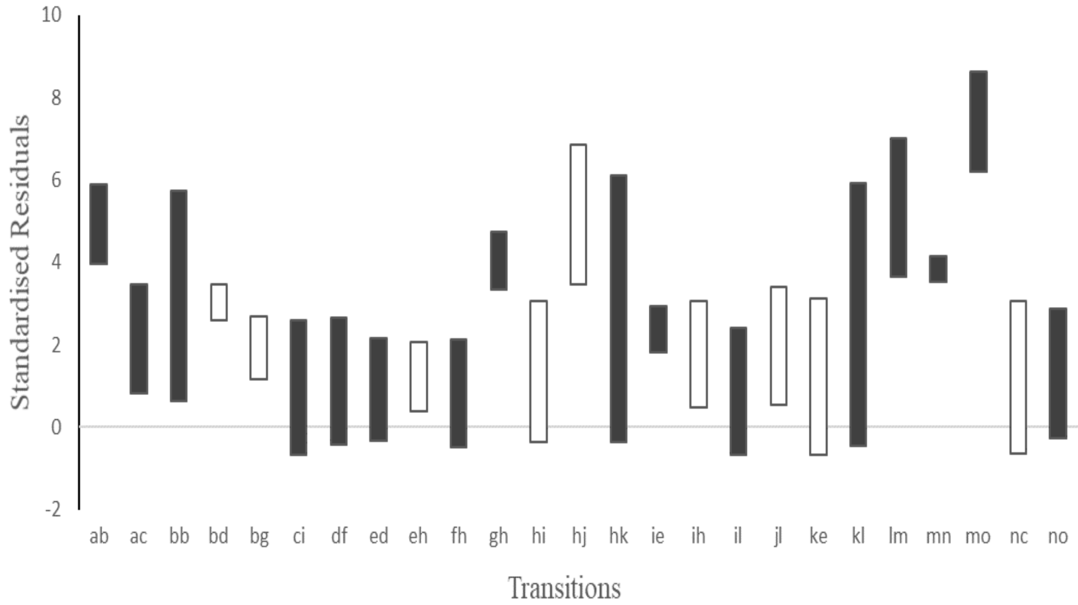
Figure 41. Chart showing comparison of standardized residuals of reported actions between those who travelled with others sub-cohorts in real-life and imagined scenarios



Note: White bars indicate the transition to be reported with greater strength of association in the imagined scenario, black bars if real-life scenario was greater.

Figure 41 shows only 9 of the 29 transitions were of sufficient strength of association in both conditions. Additionally, there were fifteen transitions that contained a negative strength of association in either condition. There are more transitions with negative values than are of similar sufficient strength. It is also interesting to note that 23 of the 29 transitions were long, black candles. This implies the transitions reported by those who imagined they travelled with others were actually more unexpectedly high than those reported by those in the real-life condition. Furthermore, 13 of these long, black candles involved negative strengths of association. This implies that these 13 highly reported transitions in the imagined scenario were reported at a lower rate than expected in the real-life scenario.

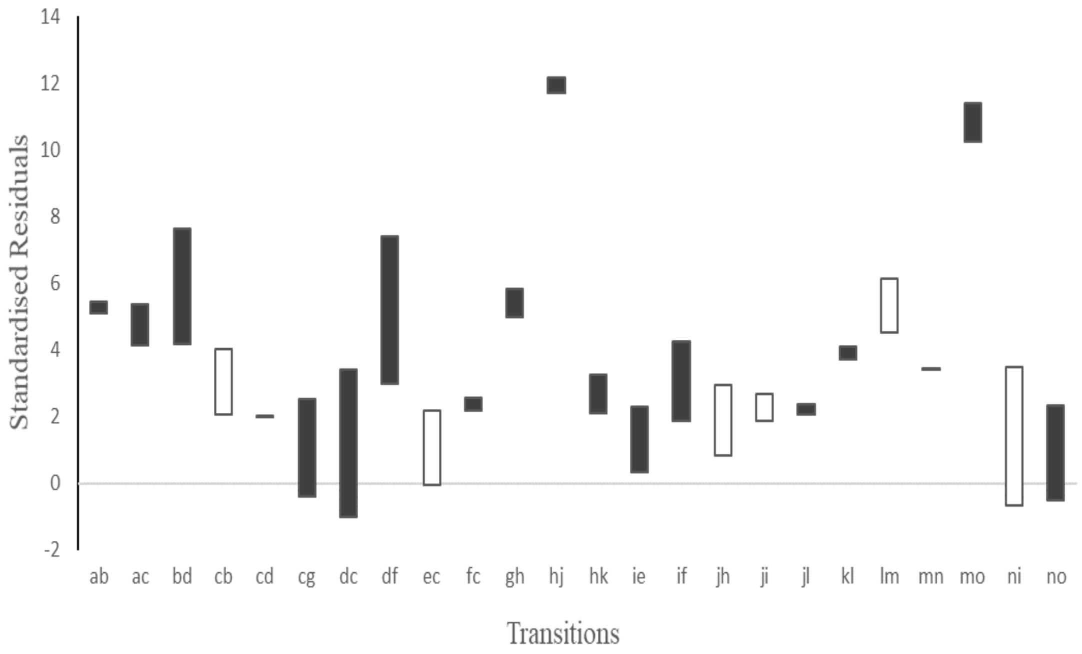
Figure 42. Chart showing comparison of standardized residuals of reported actions between those who travelled with children sub-cohorts in real-life and imagined scenarios



Note: White bars indicate the transition to be reported with greater strength of association in the imagined scenario, black bars if real-life scenario was greater.

Figure 42 shows only 8 of the 25 transitions were of sufficient strength of association in both conditions. Additionally, there were eleven transitions that contained a negative strength of association in either condition. There are more transitions with negative values than are of similar sufficient strength.

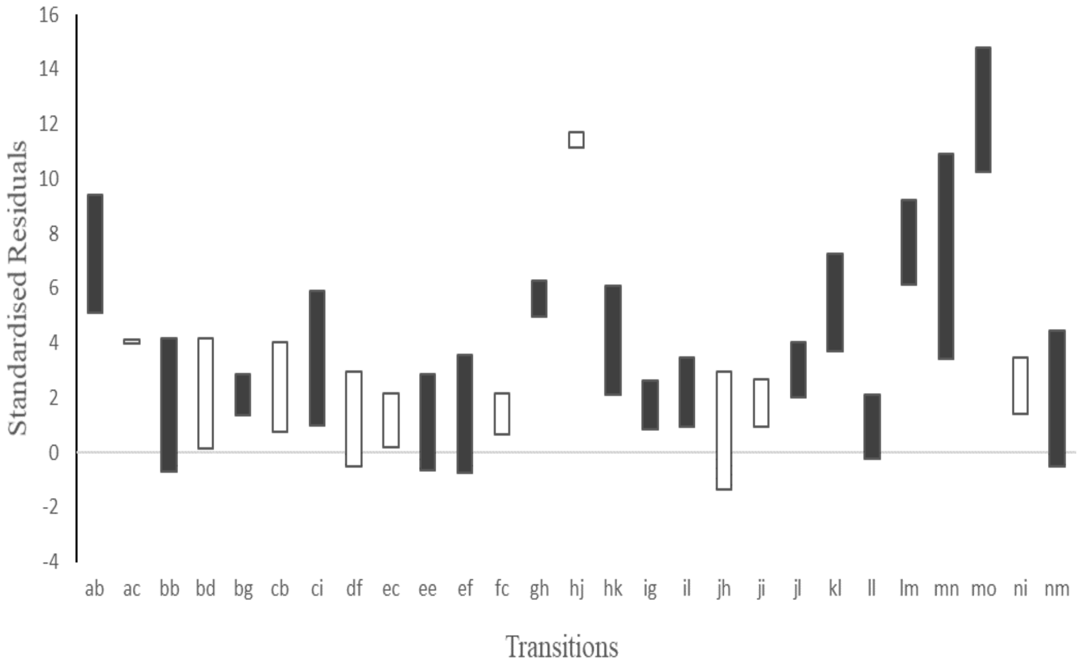
Figure 43. Chart showing comparison of standardized residuals of reported actions between those sub-cohorts with previous experience in real-life and imagined scenarios



Note: White bars indicate the transition to be reported with greater strength of association in the imagined scenario, black bars if real-life scenario was greater.

Figure 43 shows 14 of the 24 transitions were of sufficient strength of association in both conditions. This is the first sub-cohort to show similarly strong transitions to be in the majority. There were five transitions that contained a negative strength of association in either condition.

Figure 44. Chart showing comparison of standardized residuals of reported actions between those sub-cohorts without previous experience in real-life and imagined scenarios



Note: White bars indicate the transition to be reported with greater strength of association in the imagined scenario, black bars if real-life scenario was greater.

Figure 44 shows 10 of the 27 transitions were of sufficient strength of association in both conditions. There were seven transitions that contained a negative strength of association in either condition.

The results shown in Figures 35 to 44 were collated in order to show the number of pairs of transitions, which demonstrated strengths of association, which could be considered 'Strong', 'Moderate', or 'Weak'. 'Strong' was defined to be 'both greater than 2', 'Moderate' was defined as 'one greater than 2, one between 0 and 2', 'Weak' was defined as 'one greater than 2, the other less than 0'. The strength of 'greater than 2' could be demonstrated in either real-life or imagined condition (see Table 18).

Table 18. Categorised pairings of standardized residuals in real-life versus imagined scenarios

	Paired SR Strengths			
Category	Strong	Moderate	Weak	Total
Entire Cohort	15	13	6	34
Males	11	9	4	24
Females	14	11	10	35
< 41	11	8	8	27
41 to 60	13	9	8	30
>60	13	5	13	31
Alone	6	6	8	20
Others	9	5	15	29
Children	8	6	11	25
Experienced	14	5	5	24
No Experience	10	10	7	27

The pairings shown to be strong across both entire cohorts were then noted and it was examined whether these strong pairings were visible in each of the sub-cohort pairings (see Table 19).

Table 19. Comparison between strong pairings of standardized residuals in entire cohorts versus sub-cohorts

	Transitions															
Sub-Cohort	ab	ac	bd	cd	ci	gh	hj	hk	if	jl	kl	lm	mn	mo	no	Total
Males	✓	✓				✓	✓	✓		✓	✓	✓	✓	✓		10
Females	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		13
< 41	✓	✓	✓		✓	✓	✓	✓			✓	✓		✓		10
41 to 60	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓		12
> 60	✓	✓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	12
Alone	✓		✓				✓					✓		✓		5
Others	✓		✓			✓	✓			✓		✓	✓	✓		8
Children	✓		✓			✓	✓					✓	✓	✓		7
Experienced	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓		11
No Experience	✓	✓				✓	✓	✓		✓	✓	✓	✓	✓		10
Total	10	7	7	3	3	9	10	6	3	4	7	10	8	10	1	

6.3.1 Summary of Results

Comparison of transitions reported by sub-cohorts in each condition shows more differences than similarities. In each comparison except for one, less than half of the transitions considered of sufficient strength were visible in both conditions. Table 17 shows that, despite correlation analysis suggesting consistently high similarity, the only transitions that are consistently displayed across all conditions are actually very few. The final ‘total’ row suggests that the few significant transitions, meaning strong pairings of standardized residuals, present in all sub cohorts are: ‘Pre-Event Activity’ to ‘Ambiguous Perception’ (‘ab’), ‘Seek Information to Receive Instructions’ (‘gh’), ‘Receive Instructions’ to ‘Follow Instructions’ (‘hj’), ‘Seek Further Assistance’ to ‘Board Lifeboats’ (‘lm’) and ‘Board Lifeboats’ to ‘End of Involvement’ (‘mo’).

In combination, the high correlation coefficient appears to be a result of these few highly reported transitions.

6.4 Study 3 - Discussion

The comparison of acts reported in the imagined scenario versus the real-life scenario was encouraging. The numbers of each intervening act between pre-event activity and end of involvement showed a significant correlation. Further analysis of the standardized residuals as a measure of the strength of association between certain acts also suggested them to be significantly correlated. It was also encouraging to note that in each scenario approximately 50% of the 196 possible transitions were reported. Further encouragement was provided by the fact that approximately 40% of the total number of possible transitions was reported in both conditions, indicating an over-lap of 80%. However, visual inspection of the scatterplot comparing standardized residuals (see Figure 33) implied that the significant correlation noted might be a result of a few 'very strong' associations. Indeed, the majority of data points were clustered around the zero to negative area of the figure.

Consequently, additional analysis of strong standardized residuals in either condition, as entire cohorts or when compared between various sub-cohorts, revealed there to be very little consistency in measures of strength of association. Similarly, 'strong' pairings of standardized residuals constituted the majority in only a single sub-cohort, those with previous experience of cruise ships. Instead, this analysis seemed to reveal there to be certain 'vital' transitions, or gates, through which participants in both real-life and imagination all passed. All charts seem to show a 'W' shaped distribution. Transition 'ab' ('Pre-Event Activity' to 'Ambiguous Perception') is the standard entry point, followed by inconsistency until transition 'gh' ('Seek Information' to 'Receive Instructions'). This transition along with 'hj' ('Receive Instructions' to 'Follow Instructions') act as the middle peak before some further inconsistency up to transition 'lm' ('Seek Further Assistance' to 'Board Lifeboats') which precedes the standard 'end of involvement' transition 'mo' ('Board Lifeboats' to 'End of Involvement'). Further analysis of these five noted 'vital' transitions showed that four of them were consistently reported as having strong strength of association pairing across all sub-cohorts in each condition. The fifth, ‘gh’, ‘Seek Information’ to ‘Receive Instructions’, appeared in nine of the ten.

6.4.1 Correlation Analysis

As expected, the correlation between the number of acts, when described as percentages, was statistically similar. This analysis was further corroborated when examining transitions. However, of immediate concern is that the transitions in question were found to be not normally distributed. The explanation for this is provided by the way in which it was necessary to clean the data to produce such a comparison. Immediately it was noted that certain transitions showing sufficient strength of association to be noteworthy in one condition were either not reported or minimally reported in the other condition. The resultant scatterplot (see Figure 33) shows there to be certain strong transitions in both conditions. However, the majority of transitions can be seen around the zero to negative part of the plot. Nevertheless, a non-parametric correlation revealed a statistically significant correlation between the comparative ranking of all data points. That the strength of the few commonly reported strong transitions was enough to overcome the variable transitions would imply these transitions to be of vital importance.

6.4.2 Strength of Association Analysis

Visual comparison of decomposition diagrams is useful for determining the existence of a clear chain of events or recognising when certain strong transitions are replicated or absent. However, with 196 possible transitions in the present study, a more systematic method of comparison was required to provide a clear and complete view. Individual comparison of each strength of association deemed sufficient in each cohort and sub-cohort provided such a view. Through use of this method, three important factors became apparent.

Firstly, worrying variability becomes clear. Secondly, for the purposes of ecological validity, the burden of proof is upon the talk-through method to provide similar results to the real-life method. Thirdly, there exist certain transitions, which are consistently noted over all breakdowns and categorisations of the data.

With respect to the variability, the analysis undertaken exists as further evidence that correlation analysis alone may be misleading. Detecting similarities in the number of acts or transitions does not necessarily give insight into a sequence of acts (Canter et al., 1980; Wood, 1980). Even once decomposition diagrams are constructed, certain potentially contradictory evidence may not be visibly apparent. These diagrams are informative for obvious comparisons but are capable of obscuring more subtle issues. Initial visual analysis implied there to be some differences between conditions. However, it was only once systematic statistical comparison of individual transitions had been conducted that the extent of the differences became apparent.

In order to demonstrate ecological validity, it is the results of the lab-based test which must be shown to replicate the real-life accounts. It is the real-life data which acts as the benchmark 'true value'. A stark example of this can be seen in the comparison between sub-cohorts who travelled with others (see Figure 41). This figure consists almost entirely of long, black candles. This indicates that the results from the imagined cohort do not come close to replicating those reported by the real-life cohort. However, this does not mean the data are 'bad'. It is more important to be able to see inconsistencies in the data, rather than allowing simple analysis to leave them obscured. To some extent, noting that the imagined cohort seemed over-reliant on the assumed capability of others has already provided the explanation for this difference in data. However, without systematic statistical analysis this may have been missed.

Finally, despite all differences between data collection, type of interview, interviewer, imagined versus remembered accounts, differences in emotions and traits, and potential demand characteristics, the relative strength of certain transitions remains consistent. The existence of these 'vital' transitions must be recognised as a fundamental structure in further research involving behavioural sequence analysis.

6.4.3 Conclusions

The over-arching reason for research into emergency evacuation scenarios is to provide evidence for mechanisms that will increase their efficiency. This evidence consists of explanations of 'what' people do and 'why' they do it. However, there are ethical limitations and logistical issues (such as access to survivors) hindering the psychological study of real-life disasters involving accounts provided by survivors. It is possible that the talk-through method, of encouraging participants to imagine their actions in such a scenario, may provide an alternative avenue for investigation. Yet, it can only be considered effective if the data produced sufficiently mirrors that produced in real-life scenarios. In the present study, with a single exception, each and every correlation analysis suggested reports of actions and transitions to be statistically significantly similar. Further analysis suggested significant differences to be prevalent. Visual examination of decomposition diagrams indicated differences. Systematic evaluation of isolated transitions laid these differences bare. However, it was this depth of analysis that revealed possibly the most important truth – that certain transitions within a sequence of acts are vital.

The talk-through approach could be a valuable tool for psychological investigation. However, in order to conduct further research involving this approach to behavioural sequence analysis, vital transitions must be acknowledged. Similarly, it would be preferable to try to provide controls for other variability inherent in the talk-through approach. For example, a researcher introducing ‘Captain’s Announcements’ to mirror the real-life events would help to propel the imagined narrative. The minimally structured nature of interviews in the imagined scenario was shown to result in truncated implied routes. Similarly, a points system could be introduced to mirror the limits on energy and time apparent in real-life emergencies. Additionally, there needs to be reorientation towards computational model compatibility. In summation, a new methodology for the talk-through approach should be established.

6.5 Discussion of Trait Analysis

6.5.1 Overview

The present study included trait analysis for two primary reasons. Firstly, it was a reasonable way to breakdown cohorts to examine potential within-cohort differences. Once such differences became apparent it served as a possible route to providing explanations for such differences. In order to do this, the findings might be compared to similar studies, or other studies focused on the differences found. The main differences found in this study were that females undertook many more acts before attaining unambiguous perception. This may be evidence for females being more risk averse or aware of their surroundings (Kuligowski, 2009). With respect to age, it seemed older people displayed a greater tendency to follow instructions. Participants who travelled alone performed acts not correlated to other groups. Additionally, those who travelled with others acted differently to those who travelled with children. Finally, possibly predictably, those who had previous experience of travelling on cruise ships tended to attain unambiguous perception of the situation sooner (Gershon et al., 2007).

6.5.2 Similar Studies

Casareale et al. (2017) conducted a study to examine whether findings concerning evacuation behaviour as studied in buildings could also be applied to passenger ships. The aim of the research was to improve knowledge of passenger behaviour in order to produce suggestions for the improvement of the FSFE evacuation model. The study consisted of conducting experiments with simulation software and qualitatively analysing and comparing the predicted behaviour of passengers on a ship departing from the Port of Ancona, Italy. The method of investigation chosen involved questionnaires. These were modelled on existing knowledge of human behaviour in building evacuations and administered to 100 passengers. Results were then compared to qualitative data collected and analysed from videos and testimonies of the passengers of the Costa Concordia made known by the mass media. The results of the analysis of the questionnaires showed that 83% of respondents would first check the veracity of the first alarm, and that little more than half would be concerned with looking for members of their group before beginning evacuation. The decision on what to do, whether to move and if so how, was imagined to be connected to asking and following information from others by 88% of the sample. The conclusion of the behavioural study conducted by Casareale et al. (2017) supports the applicability of knowledge on evacuations of buildings to maritime scenarios. However, its most important conclusion was that emergency information is given to passengers during the emergency.

Wang et al. (2020) conducted a study on evacuation behaviour on Ro-Ro passenger ships travelling though one of China’s major routes, the Bohai Bay. The scope of the research was to try to identify and analyse demographic differences in behaviour during a possible evacuation. The questionnaires, in addition to a first purely demographic section, consisted of a series of pre-defined behaviours that the subjects were requested to rate on a Likert scale of 1 to 5. The problem of having pre-defined behaviours, albeit validated by the literature, is that of the inevitable narrowing of the possibilities of response. It also does not allow the identification or analysis of possible factors that could affect the proposed behaviours. For example, it cannot include important social and environmental interactions that would, in turn, affect subsequent behaviour. Furthermore, since experiencing an event such as an emergency evacuation is quite rare, it is assumed that the answers to the questionnaires are purely imagined or predicted. As previously discussed, imagined predictions cannot be expected to be fully accurate. The present thesis used minimally structured interviews to allow for natural descriptions of evacuations. These have informed a general taxonomy of acts which are performed during an evacuation. Further research should focus on the probabilities of moving between said acts.

The questionnaires were given to the ferry staff, to be administered to random passengers over about six weeks. Of the 1800 questionnaires 1380 were completed and validated for the analysis. The research findings highlight a number of behavioural factors found to be significant in a potential passenger ship evacuation. They reported that passengers were more likely to take the evacuation initiative after observing the behaviour of others. This effect was also noted in the present research. Those giving imagined accounts seemed to portray the assumption that others were more well informed. This mirrors the conjecture concerning a possible ‘Man Friday’ heuristic. The study also found that, generally, passengers reported a high likelihood for following instructions received. This was also seen in the present study, albeit that this effect seemed to be further moderated by age. The elder group of passengers was the one most likely to report "return when family left behind" and to help others, even more significantly when traveling within a group. This effect was not specifically found in the present thesis since it analysed these trait variables separately (not examining possible interactions). Another finding reported was that passengers with previous experiences on ferries reported a lower likelihood of collecting and carrying personal items such as luggage during the evacuation. This is perhaps mirrored in the present study with the finding that those with previous experience attain unambiguous perception sooner. It is a commonly recognised part of evacuation procedures to not be concerned with personal belongings.

A final interesting finding was that passengers predicted a higher likelihood of manifesting cooperative rather than competitive behaviour. In the imagined condition of the present study, participants showed a noticeable tendency to report their interactions with others. Although not strictly pro-social behaviour, it also mirrors the idea that others imagined to be encountered would be helpful and capable. However, it also perhaps reflects response bias in self-generated accounts. Interestingly, another study, Kvamme (2017), conducted a behaviour analysis on the Costa Concordia using the stories made available by the mass media. The study analysed public interviews and highlighted that certain behaviours contributed to evacuation problems. These included confusion, freezing or cognitive paralysis, insecurity or hesitation, and finally competitive behaviour. It would seem the 'Man Friday' effect is a figment of the imagination. Considering the nature of the event, the use of media stories can give access to important information. Yet the results of the study, such as the stories used in the analysis, must be carefully considered. Attention must be paid to stories published by journalists and blogs since they may have been written and edited with the aim of raising awareness of the story or other, ulterior, motives.

6.5.3 Gender

In recent decades, great importance has been attached to the study of risk perception for its implications in terms of safety and public health in the social sphere. Numerous studies have investigated the way in which the individual perceives the risk of certain events (Rumiati et al., 1995; Sherman et al., 2011; Slovic & Ball, 2011). These highlight a complexity that is the result of the interaction between cognitive, emotional and social factors. The results of these studies have allowed researchers to provide a relatively homogeneous picture of how individuals represent risk. The psychometric techniques adopted, typically factor analysis and psychophysical scaling, have made it possible to draw cognitive risk maps (Slovic, 2000). These portray a mental representation of risk based on two or three dimensions capable of explaining a large part of the total variance.

Research shows that men and women perceive the same risk differently (Bateman & Edwards, 2002; Cahyanto & Pennington-Gray, 2015; Hung, 2018; Shiwakoti et al., 2020). Females tend to assess risks more severely than males, and subsequently express greater concern (Eckel & Grossman, 2008; Slovic, 2000; Weber et al., 2002). The differences between females and males concern both the emotional and the rational plan. These express themselves both at the level of gravity, which involves more emotional modality, and of probability that involves more the cognitive modality (Slovic, 2000). To explain gender differences in risk perception, various interpretative hypotheses have been formulated, of which one of the most common is that relating to a biological origin (Finucane et al., 2000). The hypothesis of biological origin is linked to the different roles that led men to be more exposed and prone to risky activities. In turn, this evolved into a lower perception of risk due to experience, as well as for a certain increase of motivation towards the risk itself (Finucane et al., 2000; Vermigli et al., 2009). According to Barke et al. (1997) the role of information seems to be irrelevant to gender differences. The hypothesis that they may be attributable to greater knowledge at the level of information by males has been rejected by their studies that have shown that the differences between the two sexes in risk assessment also remain within "experts". Therefore, the same level of knowledge is still interpreted differently (Barke et al., 1997). A further interpretation calls into play the role of cultural factors. This considers the representation of risk to be an expression of the values and beliefs of society. This in turn reflects the effects of politics, culture, technology and the economy in which it develops (Becket & Nachtigall, 1994; Douglas & Wildavsky, 1982). In this perspective, the difference could be explained by the fact that, traditionally, females have had a more limited role in society in decision-making. Due to having experienced less control over risk, females' perception of it is relatively greater than that of males (Gustafson, 1998). In fact, the literature reports conflicting data on gender differences in human behaviour during evacuations. Several older studies report differences between males and females (Canter et al., 1980; Cutter, 1994; Fothergill, 1996; Riad et al., 1999) while among the most recent literature there are no significant differences (Al-Rousan et al., 2014; Bode & Codling, 2019; Kuligowski, 2011b; Wang et al., 2020). A possible explanation could be that gender roles have changed over the years, and that previous differences could be attributed to socio-political attributions rather than gender in terms of a biological factor.

There has been research into gender differences in several hurricane and disaster studies (Cutter, 1994; Bateman & Edwards, 2002; O'Brein & Atchison, 1998). Cutter (1994) reports that men tend to be more risk tolerant and that consequently more women are more likely to take protective actions in emergency situations. In 1998, O'Brien and Atchison, led post-earthquake studies, focusing on the aftershock alarms, in which they reported clear differences in behaviour between men and women. They found that women were more likely to react quickly and positively, looking for information and initiating emergency plans. As mentioned previously in this paper, gender differences were also found in building fires evacuations (Canter et al., 1980); females were more likely to warn others and seek help, whereas males were more likely to fight the fire and help others.

These findings suggest there are differences between genders in respect to risk, but there is no clear explanation as to why. The present study seems to mirror the findings that females exhibit more information-seeking behaviour, but, again, whether this is actually due to greater risk aversion or greater communicative capability is difficult to pinpoint. However, it is possible for examinations of evacuations to add to and fill gaps in current knowledge. With a new methodology more focused on the quantitative tipping points of decision-making, it may be possible to provide persuasive evidence for differences in motivation between males and females.

6.5.4 Age

Age is related to several variables relevant to evacuation such as experience, physical and cognitive abilities, perception of risk and social roles (Kinateder et al., 2015). Regarding risk perception, McLaughlin and Mayhorn (2014) acknowledged that the literature on the correlation between age and risk perception is conflicting. Nevertheless, they suggested that it can be assumed that older cohorts have superior skills in assessing risk because they are more practised with the evaluation of risk due to advancing age. There are numerous changes that occur with advancing age which can affect the perception and interpretation of cues during an emergency evacuation (Schneider & Pichora-Fuller, 2000). This is consistent with the findings of the present study that older sub-cohorts displayed a greater tendency to follow instructions. Another of the findings of the present study was that in the analysis of the survivors' testimonies and in the analysis of the acts reported by participants in the imagined scenario (see Figures 10, 11, 12, 24, 25, 26) we can see that with advancing age the strength of association between 'Follow Others' and ‘Search for Travel Companions’ is significant. These results are in accordance with Wang et al. (2020) who found a positive correlation with 'following the majority' and 'return when family left behind' to age increase. A direct quote from one of the passengers (translated from Costa Concordia survivor trial transcript, subject 16, 79 years old) is helpful to understand how observing other’s behaviour can affect evacuation: “I saw a man getting up, he looked scared…he ran to the door and left the theatre. Others started following him, going towards the exits…so then we got up and went towards the exits too." As mentioned, correlation analysis suggested aging is associated with a reduction in the reception, perception and interpretation of emergency communications and signals. This in turn is also associated with strong evidence of the statistical correlation between aging and a reduction of cognitive abilities (McLaughlin & Mayhorn, 2014). In the absence of correct perceptions and interpretations, the observation of others, and consequently the behaviour of following others, is an understandable reaction.

6.5.5 Groups

There is little previous research about the differences between the actions of those travelling alone versus those who have travelled in a group. In the literature, we can find information on the dynamics of groups in evacuations (Day et al., 2013; Friberg & Hjelm, 2014; Mawson, 2005; May, 2001; Ockerby, 2001). As already discussed in depth, social interactions are fundamental in formulating evacuation strategies (Cornwell, 2003; Johnson, 1988). Individuals evaluate and seek confirmation with other people regarding the severity of the message or the warning they received and once the social network has confirmed the validity of the warning, preventative and protective actions are performed (Aguirre et al., 1998). It is therefore not surprising that individuals who evacuate in groups tend to take longer than those who are alone (Latane & Darley, 1968; Nilsson & Johansson, 2009). This is somewhat reflected in the present study. The actions of those who travelled alone in the real-life scenario were the only which showed no correlations with other sub-cohorts. Intra-group interactions develop most frequently in groups in which emotional ties are present (Mawson, 2005). Passenger 41 (translated from Costa Concordia survivor trial transcript, subject 41) recounts that:

> I wanted to see… I saw the water, people slipping on the water...that's when I heard the first siren, I understood it was the Abandon Ship alarm and went back to find my

> husband and friends. But my husband and I got separated while going to the 4th deck, there were so many people we got lost in the crowd. I looked for my husband before going to the deck, but eventually found him there.

Despite acknowledging the abandon ship signal and the severity of the situation (water in the hallways), the passenger’s reaction was to go seek for her husband and regroup with their friends. This is an example of how emotional ties can have an effect on the assessment of and response to risk and hence delay evacuation (Sherman et al., 2011).

A further variable that can influence the perception of risk is being a parent or not. The presence of a very close emotional relationship could lead parents to overestimate the probability of occurrence of a risky event. Passenger 18 (translated from Costa Concordia survivor trial transcript, subject 18) narrates:

> We were in restaurant, my wife and my two little girls…at around 21:45 we heard strange vibrations, that became strong…then we heard a loud rumble, and the lights went off. I reassured the girls, but I knew something was very wrong. I wondered, what's the smartest decision to make right now? How can I save my children, how can I save my family?

Despite our knowledge that the event developed in a serious emergency, at the time reported, 21:45, the emergency was just beginning. The cruise ship had just impacted against the rocks (see Table 1), the situation was still under control and could have potentially been resolved. However, passenger 18 reported heightened awareness and apprehension due to the fact that he was travelling with his young daughters. Close emotional ties tend to activate a state of mind dominated by fear or concern that alters the perception of risk. As Slovic (2000) states, perceived risk depends on intuitive and experiential thinking governed by affective-emotional processes.

6.5.6 Experience

An interesting result highlighted by the studies conducted in the current research is that people without previous experience on cruise ships have reported the perception of more ambiguous factors, a greater probability of not following the instructions received and at the same time a stronger association in seeking support. The role of the 'previous experience' factor is interesting. Similarly, to social factors, having previous experiences can have both positive and negative effects on the effectiveness of evacuation (Proulx, 1993; Rando et al., 2007; Wachinger et al., 2013). It is important to underline that in the studies conducted in this research, the 'previous experience' consisted in having taken part to previous cruises, and not having experienced an actual evacuation. The role of having participated in traumatic events or emergency evacuations is often discussed in the literature. For example, in the review by Wachinger et al. (2013) it was concluded that having lived similar experiences previously is a significant factor that influences one's perception of risk. Although previous experience may increase the probability of preventive and precautionary behaviour, it can also create false securities, decreasing one's awareness and consequently the capability to effectively assess the situation (Fitzpatrick-Lewis et al., 2010; Wachinger et al., 2013). For example, one of the survivors of the Costa Concordia accident recounted that he didn't think much of the initial cue of strong vibrations "Since I'm an experienced cruiser, I've been on at least twelve cruises, I wasn't scared, it was normal…sometimes these strong vibrations happen, it's just the engines" (translated from Costa Concordia survivor trial transcript, subject 32). This is an example of the effect previous experience can have on decreasing one's awareness.

In a study on building evacuations, Till and Babcock (2010) found that subjects with previous experience were able to evacuate faster than others. Their conclusions report that people without previous experience are already at a disadvantage. The lack of knowledge of evacuation procedures and emergency signals could be factors affecting the higher evacuation times reported by the group. The use of an integrated sound and vocal communication system represents the best mechanism because the pure sound signal simply has the task of stimulating attention (Omori et al., 2017). This then provokes questions about its meaning, so much so that, if not supported by other information, the person will use their personal experience and the general context in which they find themselves to get a reading of what is happening (Zuliani, 2013). A clear example of this was found in the testimony of Passenger 50 (translated from Costa Concordia survivor trial transcript, subject 50):

> We heard a siren and at that point, not knowing where to go, we had no other indications, we followed the fleet of people who were running away. Clearly not knowing what to do, we started going up then we started following other people who went down then we got to bridge four…yes four, where the lifeboats are.

Passenger 50 had no previous experience on cruise ships and reports not knowing what to do and following others after hearing the abandon ship signal. Being unaware of the meaning of the signal and not knowing the evacuation procedures made the option of following others the most reassuring. In other words, the sound signal acts on the emotional side, but, in itself, it does not provide adequate cognitive support to give meaning to the activation triggered.

Furthermore, it is not only the quality of information that matters. Returning to the social aspects, the trust placed in the source of information can also have significant effects on human behaviour during the evacuation (Fitzpatrick-Lewis et al., 2010). Passenger 29 (translated from Costa Concordia survivor trial transcript, subject 29) clearly states that he didn't trust the information received "they said it was an electrical problem, a failure… but I didn't believe it. So, I told my friend to follow me, and we went to Deck 4 where I remembered seeing lifeboats and waited there." In retrospect, we can say that heading to the mustering station was in fact the best outcome, however trust in crewmembers, or lack thereof, is an important aspect of the evacuation process. Emergency communications need to be improved, both with regards to the quality of the communication and with regards to the training of the staff.

6.5.7 Conclusions

The trait analysis in the present study was able to pick out certain differences in sub-cohorts categorised by certain traits. Overall, it was discovered that in all comparisons bar one, strong transitions reported in both conditions were in the minority. The starkest example of this can be seen in the comparison of those who travelled with others (Figure 41). Here it can be seen that those transitions reported most highly unexpectedly in the imagined condition were minimally reported in the real-life condition. Links have been shown with certain pre-existing psychological theories. Yet, some of those theories, for example reasons for risk-averse perceptions in females, would still benefit from further evidence (Kinateder et al., 2015; Sjoberg et al., 2004; Weber et al., 2002). With a new methodology, research similar to the present thesis may be able to fill some of these gaps in knowledge.

6.6 Limitations of the Current Methodology

The intention of the present thesis and previous research (Canter & Finiti, 2015) is to provide foundational evidence towards the creation of a psychologically sound behavioural decision-making model for evacuation scenarios. Ultimately, such a model should be capable of informing computational models, concerned with the speed and directions of actions, and with the tendencies and choices involved in people's actions in order to construct a complete model. In the present thesis, Study 1 provides some unique evidence towards this goal. Accounts of real-life survivors of the Costa Concordia have been coded and show significant similarity to those accounts of other survivors. These coded accounts then provide insight into a generalised chain of acts, which occur during the initial stages of a disaster. However, the persuasiveness of this evidence is only a function of the rigour, depth, and adequacy of the methodology. Initial data was collected through coding of survivor accounts. Follow-up data was collected through the talk-through method (Lawson, 2011). Both methods exhibit potential flaws. That the data extracted in each study was adjudged to be statistically significantly similar was evidenced by correlation analysis. That such a reliable chain of initial acts was visible in the real-life study was evidenced by stringing together ‘strength of association’ calculations. The creation of the chain of events required an additional ad hoc simple standardised residual to base rate ratio calculation. It could reasonably be argued that behavioural sequence analysis is a misnomer as it is incapable of rigorously analysing entire sequences.

Study 1 of this thesis has provided good evidence for the existence of a collection of acts, which can be combined to describe real-life maritime evacuation sequences. Study 2 has provided evidence for these acts being sufficient to also describe imagined evacuation sequences. These acts may constitute the basis of a simple behavioural model. It is the open nature of minimally structured interviews, which has allowed this collection of acts to be revealed. However, the beneficial insights gained from freeform verbal reports come at the cost of controls and comparability. The standardized residuals and base rates calculated for transitions have hinted at both ecological validity with respect to collective correlations and stark differences when comparing conditions. To more fully investigate transitions within sequences, more comparability through controls is required. This could take the form of a participant navigating their way through an evacuation via one of a multitude of pre-determined routes. The prevalence of each entire route would be easily comparable. Furthermore, it would then be possible to compare each choice within each phase of each entire evacuation sequence. Controlling the possible transitions and sequences will allow for a more robust examination of the choices and behaviour involved in evacuation scenarios. Research into evacuation procedures requires reorientation.

Finally, it must be recognised that computational models, and probabilistic cellular models in particular, rely on probabilistic data to drive shifts between states. As discussed above, such probabilistic psychological data may be acquired with a reorientation of research. However, these probabilities would still only describe transitions between acts rather than explaining why people act in certain ways.

Previous studies have given a statistical view of the acts that occur but have not provided an analytical explanation for the decision-making involved in those acts. However, this is another avenue which would benefit from a reorientation of investigation. Greater control over the possible transitions for examination would allow for greater focus on possible social or heuristic influences on choices. Rationality is not only based on qualitative decisions, but also quantitative evaluations. These quantitative evaluations may be affected not only by the traits of the individual, but also the aforementioned social factors and heuristic short cuts and biases. In a high-pressure environment, such as a potentially life-threatening disaster scenario, these quantitative evaluations may drive decision-making. Every choice involves a balancing of risk and reward in terms of limited resources of safety, health, or time. An appreciation of such quantitative costs and associated tipping points must be appreciated in conjunction with choices based on certain qualities.

6.6.1 Limitations of Survivor Accounts

Survivor accounts are first-hand evidence which may provide insight for understanding human behaviour over the course of the evolution of an emergency evacuation. The reports can provide unique information regarding not only the event itself but also the complex processes of decision-making during extreme, uncertain conditions. Numerous studies of land-based evacuations have been conducted using survivor reports (Averill et al., 2005; Canter et al., 1980; Drury, 2006; Galea et al., 2007; Kuligowski, 2011b; Proulx &

Reid, 2006; Wood, 1980). These have provided certain valuable insights into the course of human behaviour, such as different factors influencing different stages of the emergency decision-making process. However, there are several limitations to use of such reports as part of a methodology. When studying disastrous events with fatalities, the exclusion of those who didn’t successfully evacuate implies that the sample cannot be completely representative of the whole population (Gershon et al., 2012; Wood, 1980). It is important to understand routes to successful evacuation, but it would perhaps be even more enlightening to be able to examine decision-making, which ultimately led to an unsuccessful sequence of acts. This would be possible in a controlled, refined version of the talk-through method where either a chosen sequence of transitions of acts led to an unsuccessful evacuation or a terminal depletion of resource points. Additionally, accessibility to survivor reports is extremely limited. This is mainly due to the ethical considerations involved in requesting a participant to provide a recollection of a traumatic experience. Ideally, survivor accounts would be obtained from well-designed interviews using open approaches to data collection, allowing for detailed data. It would also be preferable to conduct these interviews as soon as possible after the event in question. This is a vital step, as survivors’ memories could be affected by numerous factors such as time, emotions, knowledge and external factors (D’Ambrosio, 2010). Due to the limited accessibility, survivor accounts are rarely obtained in scientific studies through the conduct of interviews. In the present and previous study (Canter & Finiti, 2015) the accounts examined were obtained during legal interviews. As previously stated, the intent of these interviews was to determine a sequence of events to assess liability. This intent may have impacted on the results. It was noted that in the real-life scenario there existed a greater tendency to ‘Seek Information’ rather than ‘Follow Others’. This might be a result of legal questioning directed towards the capability and culpability of the crew with respect to their communication of vital safety information. More commonly, personal accounts and interviews made available through media and press are used, despite the limitations. Media reports may be tainted. Journalists may sensationalise and focus on specific aspects of the stories (Averill et al., 2005). Reports can be edited, and questions be directed towards the outlet's ultimate goal of attracting and retaining readers and viewers. These accounts, despite their limitations, can still provide useful information, especially due to the fact that they are often collected soon after the event of interest. Unlike media reports, scientific interviews are rarely conducted soon after an event due to the time constraints involved in design and preparation (Blake et al., 2004). Sometimes, survivor accounts are collected years after an event. These may be inaccurate due to expected memory issues. Furthermore, accounts provided may be biased or modified as a result of exposure to information made available through mass media such as other reports or debates. However, despite the limitations discussed, conducting interviews with survivors as part of a scientific project is still the optimal form of data gathering. In order for other possible forms to be considered acceptable, persuasive evidence must be provided for their ability to accurately replicate real-life accounts.

6.6.2 Limitations of the Talk-Through Method

Human behaviour is extremely complex. This is compounded when examined within the context of a complex, rapidly changing, potentially life-threatening scenario such as a disaster or evacuation. As discussed throughout this thesis, emotions play an important role in human behaviour. Emotions alter various cognitive tasks such as the reception of cues, our perception and understanding of them, risk perception and decision-making (Kinateder et al., 2015). Expecting a real-life survivor to recount such an experience would be ethically questionable. The talk-through method minimizes this ethical issue, but at the cost of the vigilance required when interpreting results of accounts provided with minimised emotional involvement. Nevertheless, initial results of correlation analysis suggested a significant similarity between the acts and behaviours reported in the Costa Concordia survivors' accounts and the actions imagined having been performed which were reported in the talk-through study. Indeed, prima facie, these would suggest the results from the different approaches to be similar enough to consider the talk-through approach to be a valid method to predict human behaviour in maritime evacuations. However, this is perhaps surprising in the knowledge that the aforementioned emotional component has been minimized. Although the data shows significant correlations it would be unwise to expect an imagined prediction of one's behaviour and emotional state to be accurate. In the present study, it was decided to retain as an act the report of negative feelings. An important component of rationality is the ability to cope with emotions. Certain strengths of association were noted between acts and this 'emotion' act, but it did not for any part of the 'vital' transitions.

In the talk-through methodology, imagined accounts do not allow for the investigation of details linked to the environment and appropriate feedback from social interactions. Environment and social interactions have been consistently found to be significant influencers of behaviour in emergency evacuations (Cornwell, 2003; Fritz & Marks, 1954; Galea, 2009; Gershon et al., 2012; Mawson, 2005). Indeed, further analysis of the results provided by the talk-through method immediately demonstrated high strengths of associations of acts involving others. As discussed, this may be an artefact of the style of interview or the participants' mistaken conception of the purpose of the interview. In the present thesis, it is possible that participants may have thought the purpose of the interview was to examine their altruism or heroism rather than the sequence of acts involved in their imagined evacuation. Another possibility is that there exists a form of 'Man-Friday' heuristic. If one imagines oneself in a dangerous situation, does one automatically assume those around us to be driven, capable, and efficient as a comforting mechanism? This proposed novel heuristic is supported by the findings of the present study which showed acts involving others to be more prevalent in imagined accounts.

The present study contained an attempt to demonstrate the validity of the talk-through method. Indeed, it fills a gap in the knowledge, the comparison of real-life accounts, specifically highlighted in a previous study (Lawson, 2011). What the present study has demonstrated is that at a collective level of analysis, results show significant similarities. That the counts of similar acts and transitions found in real-life versus imagined accounts were similar is an encouraging novel finding of this thesis. However, as depth of analysis progresses, these similarities disconnect. The talk-through method could prove valuable in the future, but its execution and direction need refining. It would be ethically irresponsible to aim to recreate the emotions involved in an emergency, so this inaccuracy simply needs to be acknowledged. However, other inaccuracies might be remedied. For example, that the imagined experience does not necessarily reflect reality might be accounted for through greater, more interactive description. The type of interview through which accounts are reported also seems to influence results. Similarly, participants imagining events may be mistakenly providing the wrong type of storytelling due to demand characteristics. These issues may be corrected through structuring the interviews. This will also enable a researcher to extract the exact information required, possibly including motivation. Different types of accounts rely on different mental sources of information. Potential flaws in memory afflict real-life accounts, similarly, imagined accounts are afflicted by potential flaws in imagination. To remove these flaws a more interactive storytelling mechanism is required. Additionally, including a form of quantitative measurement of ‘act cost’ would provide better data for more rigorous analysis. Such refinements may allow reorientation towards a more efficacious methodology for the investigation of behaviour in emergency scenarios.

6.6.3 Limitations of Sequence Analysis

Sequence analysis is not a novel method. In 1986, Bakeman and Gottman published the first edition of their book "Observing Interaction: An introduction to Sequential Analysis". It was the first comprehensive introduction to sequential analysis, providing insight on a methodology for observing and investigating social behaviour. Behavioural sequence analysis allows for the identification of various variables within a system, along with their function, connection, and contribution to the system overall (Keatley, 2019). Behavioural sequence analysis is, however, still an under-used method. Despite its ability to provide insight into the complexities of human behaviour, behavioural sequence analysis can be considerably time-consuming. Data collection and data coding are the first two steps of the procedure. As previously discussed, the limitations and variability involved in collecting accounts mean this initial step may be a lengthy process. Similarly, the coding of the accounts requires several read-throughs and multiple iterations of variable taxonomies. For example, the Costa Concordia survivor transcripts were, at times, as long as 300 page each. However, as discussed, such a meticulous process for producing data points still leaves critical gaps in knowledge. It is uncommon to be able to account for time-interval sequences, the co-occurrence of behaviours, and causation. Consequently, it is ill equipped to extract and isolate motivational factors.

A further limitation is that the method does not provide an overview of the comparative value of sequences. Every account is not considered as a holistic sequence, but rather as a series of discrete transitions. It is only the total number of transitions which is examined rather than their potential value within any sequence of which they are a part. This issue is further compounded by the survivor bias within data collection. There are no fatal transitions. Instead, every account of evacuation is successful, with every transition being considered of equal importance. There is no value ascribed to any act or transition. It is only once deeper analysis has been undertaken that differences in importance can be detected. In the present study, these have been described as ‘vital’ transitions. However, this is still only a qualitative, categorical difference. For behavioural sequence analysis to become a reliable methodology for the investigation of emergency evacuations, it needs to evolve and adapt solutions to these fundamental issues.

6.6.4 Limitations of Statistical Analysis

The fundamental flaw of the analysis currently available in the methodology used in the present study is that all comparisons are self-referential. The calculations of expected values of transitions and base rates are based on the number of acts reported. This resulted in an uncommon act (‘Encounter Problems Evacuating’) being part of the most consistently unexpectedly highly reported transitions. It is perhaps misleading to label these as important transitions. There is neither an objective optimum nor an asymptotic horizon with which to compare values. Consequently, all values are compared to manipulations of themselves. A further consequence of this is that different levels of analysis produce contradictions. An example from the present study is the correlations calculated to be significant to the .001 level. These also imply large r-squared effect sizes, which would imply the data to be very similar. However, further analysis shows only 5 of 196 transitions to be reliable, this would imply the data to be dissimilar. It is important to remain appreciative that these contradictions will exist. It is of further importance to be focused on which particular level of analysis is most important in a study. In the present study, following behavioural sequence analysis, it seemed a clear chain of initial events had been statistically described. Initially, this seemed to be an encouraging finding. However, deeper analysis suggested the variability of transitions within this sequence meant such a chain of events should be acknowledged with caution.

Initial correlation analysis is generally considered a check on data. Indeed, in the present research, the first part of the first study was a correlative check of new data versus data obtained in a previous study (Canter & Finiti, 2015). This check was not a check of complete sequences or indeed transitions, but simply the number of acts reported. Similarly, initial checks were conducted to compare the reported actions of the imagined cohort to the real-life cohort. In each of these comparisons, the prior data should be considered a 'truth' to be replicated. It is important, as a test of reliability, to know that the new data from the original population from which the data of the previous study were taken are similar. It then becomes important, as a test of validity of the talk-through method, to ensure imagined data approaches the truth of real-life data. The high correlations would suggest these truths have been suitably replicated.

Further correlation analysis concerning the comparison of transitions also highlighted potential cautionary flags. The Shapiro-Wilk test showed these data to be not normally distributed. Distributions tend not to be perfectly normally distributed. There is usually an element of kurtosis to either side of the normal. This may involve platykurtosis or leptokurtosis or exist as log-normal distributions. However, the main issue with tests of normality is that once the threshold of non-normality is crossed statistically, the method of correlation becomes further simplified. Instead of comparing specific transitions, it compares the ranks of transitions. There already exist issues of not comparing holistic sequences, and that comparisons are non-hierarchical. Judging similarities through rankings is simply another step further from the required understanding of the value of acts and transitions.

The 'strength of association' calculation used to describe transitions is similarly flawed by its self-referential nature. The fundamental issue exists with the method of calculation of 'expected values'. As previously stated, the current methodology is based upon minimally structured, non-controlled interviews, which lead to problems when attempting comparisons. Therefore, what is ‘expected’ is calculated from the data itself. For transitions, this is calculated probabilistically as the likelihood of one act following another given the total number of times each and every act occurs. The main problem with this method is that it ignores the existence of acts as part of a sequence with a defined beginning and end. Essentially, any act could follow any other. Theoretically, this is possibly true. However, in reality and bearing in mind the storytelling form of data gathered, this will not happen. Thus, the current method overweighs impossible, or non-reported, transitions. An alternative to this method is simply to calculate expected values from those transitions, which actually did occur. However, this then reverses the problem. In this case, it is the minimally reported ‘odd’ transitions which then have their influence over-weighted. A single report of an odd transition from one act would then magnify the strengths of association of all other transitions from that act.

Each method of calculation of strength of association has limitations. However, during the present study of trait differences a better compromise was found. Instead of self-referential calculations based on acts of each sub-cohort, the expected values of the entire cohort were pro-rated. This is still not a perfect solution. Pro-rating an expected value calculated with a certain ‘N’ means that if we then multiply by ‘n’ parts of ‘N’, the difference between these two numbers of participants is not accounted for within the expected value calculation. However, this essentially means sub-cohort strengths of association were calculated more stringently. As the purpose of these comparisons was to highlight differences, this particular method of calculation was beneficial.

6.6.5 Conclusions

Ultimately, to produce persuasive evidence requires a rigorous methodology. The best method currently available, based on verbal report, for the psychological examination of evacuation routes is behavioural sequence analysis. However, the current methodology displays issues with data collection, analysis, and general direction of investigation. The talk-through method needs refinement before it might be able to prove its value. Similarly, the data points produced and the methods available for their analysis are insufficient. Any conclusions drawn must be done so with wariness. Furthermore, any evidence gained is not in a suitable form so as to be compatible with more quantitative, computational modelling. Behavioural sequence analysis and the talk-through approach need to evolve and refine in order to be of use in the examination of evacuation scenarios.

Chapter Seven: A Proposal for a New Method for Evacuation Research

7.1 Overview of Current Issues

Currently, psychological investigation of evacuations is restricted by several factors. Real-life relevant data is difficult to collect due to ethical issues, scarce first-hand sources, and flaws involved in retelling a story of an emotional event from memory. The talk-though method, involving imagined accounts, is, as yet, unproven. It is also subject to issues involving demand characteristics and flaws in imagination. Even once data is collected and data points created, these are misdirected in terms of revealing psychological motivations. They show the acts that occurred but not the reason for their occurrence. Similarly, the data points rely on whether or not a participant either remembers or chooses to imagine an act occurring. Furthermore, while the open, non-controlled nature of interviews reveal certain insights into acts and transitions, the evaluations provided are difficult to compare. All examined evacuations are successful, rendering each chain of events equal, meaning there is no measurable value to any particular act. This artificial equality has ramifications for the data analysis possible. Comparing the number of acts gives no insight into their relative importance of positioning within sequences. Obtaining expected values from a calculation that assumes any transition is equally possible is ignoring the fundamental objective of analysing sequences. Consequently, a lack of precise measurement makes it incredibly difficult to extract evidence with respect to the perhaps subtle variations caused by differences in participant characteristics.

These issues essentially fall into three categories: issues with accounts, issue with data points, and issues with data analysis. It would be preferable to be able to produce accounts in a lab setting. The issues with collecting reliable real-life data have been discussed. However, it has also been noted that refinements are required to the current talk-through method (for example the introduction of external cues for progressive phases of the evacuation). Therefore, there needs to be a redirection of how a participant's story is told. Similarly, to create data points which will be psychologically enlightening there needs to be an increase in focus on motivations. Choices may be made for qualitative or quantitative reasons. Therefore, there needs to be a greater emphasis on producing measurable variables within sequences of acts. Similarly, there need to be measurable variables associated with the success of overall sequences which may be broken down into the individual valuation of acts themselves. These variables may indeed allow for description and evaluation of non-successful evacuations. Finally, data analysis needs to be more adaptable to computational modelling. This would require greater definition of original inputs, which in turn may be combined to create a single measurable output.

7.2 Improving Accounts

As discussed, the ability to produce accurate imagined accounts would be of great benefit to the examination of evacuation behaviour. The talk-through methodology (Lawson, 2011) used in the present study relies on an unrestricted account given freely by a participant. If necessary, this account is sometimes guided by the researcher, but it is essentially a story which is the product of the participant's imagination. Similarly, the real-life accounts used in this study were the product of interviews guided by legal professionals. It has been demonstrated how these different types of guidance might affect the data points created. Such open, naturalistic accounts are important in the early stages of psychological investigation. They tend to provide rich, detailed data, which are not overly influenced or biased by the researcher's assumptions. Indeed, they often give rise to potential issues not previously considered. Such accounts are a standard tool in qualitative methodology. However, as discussed, the current methodology is in need of redirection towards more quantitative investigation. Probabilistic cellular models require well-researched probabilities of state changes. Furthermore, encouraging unrestricted imagined accounts may not prove enlightening. The storytelling may be unrealistic or overly concerned with elements of no interest to the required investigation.

The present thesis has provided good evidence that a maritime evacuation may be described through sequences built up from a taxonomy of acts. Ultimately, psychological investigation is interested in decision-making. Therefore, it is not only the actual acts undertaken which should be of interest, but rather, if the participant is faced with a choice between acts, which one do they choose and for what reason. Thus, it would seem beneficial for all possible acts to be predetermined. The participant's role would then be the efficient and explained navigation through the acts required for examination by the researcher.

With the role of storyteller transferred from participant to researcher, the efficiency and success of outcomes could also be pre-determined as a function of choices. It would be possible to create an optimal route through the story. This alone has ramifications for the quality of data produced. This will be discussed in detail at a later point. Similarly, there would be sub-optimal routes to different extents. By extension, this would also allow for the creation of certain non-successful routes of evacuation. As in real-life, if a participant were to disregard cues and ignore instructions, there would be a limited likelihood of success. Similar punishments could be ascribed to those who act recklessly or in an over-cautionary manner. Such a set-up would also help the integrity of data collected through filtering uncommitted participants. It might also be used as a device to promote motivation in participants through extra incentive given for the most efficient path created.

This idea of motivation might also be used to represent the insurmountable difference between real-life and imagined accounts: heightened emotions. In addition to navigation through the most optimal route to successful evacuation, there might also be applied an element of real-life timing. Thus, the extra incentive might be awarded to the participant with the most optimal route considered in both relative action terms and real-life time taken. This knowledge that they are working ‘against the clock’ may act as a very subtle replication of the heightened emotions affecting the cost-benefit analysis involved in decision-making. By taking control of the story, it becomes far easier to create the conditions appropriate to the decision-making under examination.

Finally, and most crucially, by transferring the focus of participants from storytelling to motivations for choices it is possible to ascribe values to acts and costs to choices. The present study has demonstrated the existence of ‘vital transitions’ within sequences of acts. The inscrutable variability exists in the choices between acts that exist between these vital transitions. Therefore, it would seem logical for these vital transitions to constitute the rigid spine of the structure of the story. They would act as gates to be passed through by each participant. However, how they approached those gates, and the intervening acts they chose to undertake to get there, would be far more available for examination with the introduction of act values and decision costs. Furthermore, the precise granularity of information required by the researcher is set by the researcher. This may then be modified as required.

7.3 Improving Data Points

One aim of the present study is to try to determine whether imagined accounts are able to replicate real-life accounts. If they are, then this becomes an easy, low-cost method for collecting data for examination with the purpose of improving evacuation procedures. Indeed, the present study demonstrated that, when considered collectively, the acts reported in real-life and imagined scenarios were similar. However, in neither scenario is it enough to simply know what acts were undertaken. The consequences and efficacies of these acts need quantification. At present, there is no method of analysis possible which will accurately quantitatively compare an entire sequence of acts performed by one person versus another. In the present and previous studies, the only output is successful evacuation. This is essentially a singular outcome. All successful evacuations are equally successful. However, even from the data collected it is possible to detect differences in evacuations. Some are efficient as opposed to hesitant. Others are socially directed rather than goal directed. Imagined scenarios seemed to rely on the capability of others as opposed to real-life accounts relying more on instruction. However, there currently exists no way to quantitavely differentiate between these different strategies. There is no objectively optimal strategy with which to compare other strategies.

As discussed, if the role of participant is reduced to decision-making, the story may be controlled by the researcher. The story would have a defined starting point, certain events would occur, certain vital transitions would possibly, but not necessarily, be undertaken, and a multitude of possible endings may be available. Any possible route would require a quantitative value. To create this overall value, every possible choice would incur a quantifiable cost.

For example, the following could be the opening page of an interview script:

Page 1

‘You are travelling alone on board a beautiful cruise liner. You are sat in the middle of a well-lit, ornate restaurant. There is a door in the middle of each wall, and ship’s crew dotted around the place. Your meal has just arrived, and you are hungry from a busy day. The restaurant is full, with everybody enjoying their time.

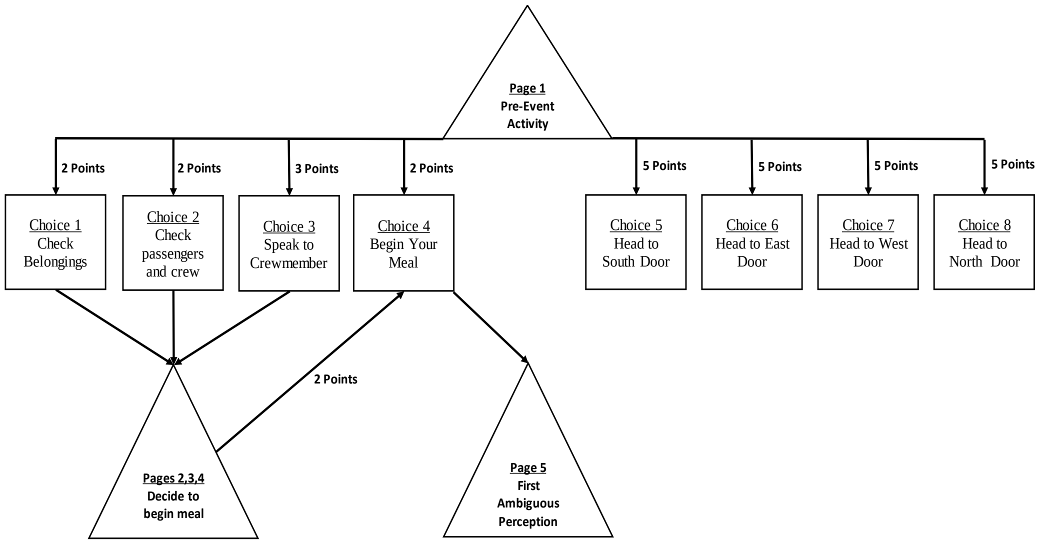
What do you decide to do?

1. Check all your belongings	(2 points)	Go to Page 2
2. Check the other passengers and crew	(2 points)	Go to Page 3
3. Find a crew member to speak to	(3 points)	Go to Page 4

4.	Begin your meal	(2 points)	Go to page 5
5.	Make your way to the South door	(5 points)	Go to Page 6
6.	Make your way to the East door	(5 points)	Go to Page 7
7.	Make your way to the West door	(5 points)	Go to page 8
8.	Make your way to the North door	(5 points)	Go to page 9

Such a page would constitute the pre-event activity moment of the evacuation. As can be seen, the first four choices are fairly simple with low associated points costs. The following four choices involving actions accrue higher points cost. The story may be constructed so the first intermediate vital transition is to be ‘4. Begin your meal’. This then brings about an event such as ‘Initial Impact’ which would constitute the first ‘Ambiguous Perception’. An example of how this could be constructed is shown in Figure 45. As this is the pre-event activity, it would seem correct to carry on as usual in the knowledge that you are hungry, and your meal has just arrived. As can be seen, making the ‘correct’ decision only incurs ‘2 points’ before arriving at the next vital juncture. Other decisions incur an extra 2 or 3 points before arriving in the same situation. This would constitute a small punishment for over-cautiousness or unnecessary acts. Similarly, any act of heading towards any of the doors incurs a relatively high cost. As everything seems fine, and your meal has just arrived, this would seem an irrational act. The extra 5 points incurred would constitute a punishment for recklessness.

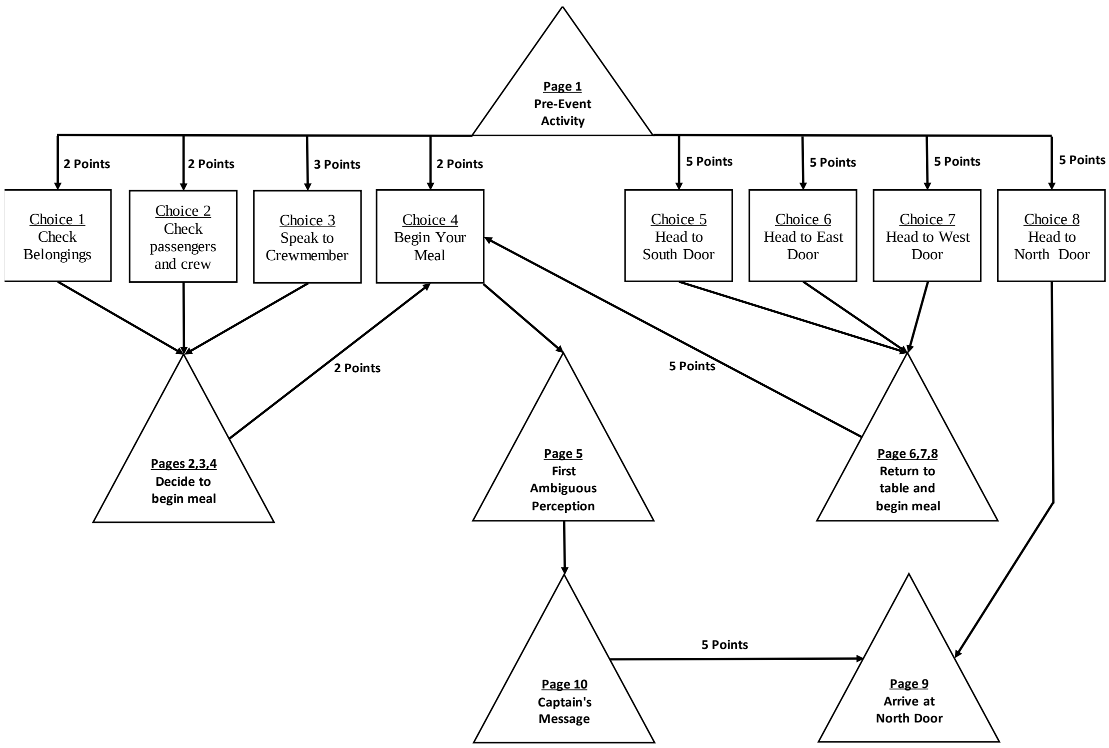
Figure 45. Schematic to show possible first stage of potential new interview methodology



However, the ultimate objective of this story is efficient evacuation. In the same way that recklessness should be punished, there should be some reward for good fortune. Initiation of evacuation will not take place from the middle of a restaurant. Therefore, the story might be constructed so that the first ambiguous perception was followed by an announcement from the ship's captain informing everybody of the situation and that they should head towards the north door. With no prior knowledge or rationality, Choice 8 was actually the most optimal route to evacuation (see Figure 45).

As can be seen from Figure 46, this initial part of the evacuation shows four basic route strategies: 'rational', 'over-cautious', 'reckless', and 'fortunate'. Like standard behavioural sequence analysis, it would still be possible to count the number of acts committed and transitions undertaken. However, unlike standard behavioural sequence analysis, each sequence of acts is now relatively quantifiable. The overall vital transition is moving from 'Pre-event Activity' to 'Arrive at North Door'. The 'rational' route consists of simply beginning the meal, then receiving the first ambiguous perception before the captain's message and subsequently following instructions to move towards the north door costs 7 points. The 'over-cautious' strategy includes the additional unnecessary act before beginning the meal which results in a point punishment resulting in an overall cost of 9 or 10 points. The 'reckless' strategy involves heading to an incorrect door before beginning the meal which results in an overall cost of 15 points. The 'fortunate' strategy is heading straight to the north door without reason but results in an overall cost of 5 points.

Figure 46. Schematic to show possible extended first stage of potential new interview methodology



These schematics serve as an initial example of a simple transition. However, it demonstrates the added strength of quantifiable sequences which show characteristics such as rationality and recklessness. Additionally, these particular examples exhibit a certain granularity. It would, for instance, be possible to insert choices and costs between 'First

Ambiguous Perception' and 'Captain's Message'. The granularity and focus of investigation are up to the researcher as storyteller. It would also be possible to introduce loops to punish the over-cautious or over-inquisitive. As previously stated, it would also be possible to introduce non-successful ends of involvement for the terminally reckless.

Another avenue of potential enlightenment concerns possible experimental manipulation of point costs. As previously stated, choices may be made due to quantitative reasoning, especially in situations with heightened emotions. It would be of interest to understand potential tipping points where instructions might be ignored due to quantitative evaluation. For example, a participant has been instructed to go through a door and then go left down the corridor to exit through the door at the end. However, once the participant goes through the first door, they see a door immediately in front of them and another door down a shorter corridor to the right. If the points cost of exploring the left door is 'x' and the other two doors 'y' and 'z', at what ratio of 'x to y' or 'x to z' are instructions followed perfectly. It would be possible to manipulate these costs to encourage participants to undertake the unnecessary, or perhaps fortunate, act of investigating a non-instructed door.

Enabling the quantitative comparison of choices and sequences would make the current methodology far more powerful and enlightening. It would become an examination of the choices made rather than the acts committed. A fundamental addition could be a page asking the participant what motivated them to follow each choice. This would provide a route to investigation of the motivations responsible for transitions between discrete acts. Enabling experimental manipulations of variables would also be able to shed light on the cost benefit analysis undertaken in quantitative decision-making. At first, it may appear to be an extensive investment of time to prepare such a potentially complex story involving perhaps hundreds of decisions and multiple endings. However, the researcher would be responsible for the creation of the precise data to be explored. It has already been discussed that there are flaws in the current methodology concerning data collection and the creation of data points. By transferring the control of stories to the researcher, these flaws can be remedied.

7.4 Improving Data Analysis

The current methodology needs to move away from simplistic correlations and self-referential calculations of standardised residuals. To be compatible with computational modelling, psychological modelling requires a greater focus on producing quantitative outputs from categorical and numerical inputs. In the present study, an exploratory examination of the role of traits in evacuation was undertaken. Despite the limitations of the data and analysis, certain key differences were detected. However, there was no clear way to quantify these differences. In order to quantify the role of traits, it is necessary to perform statistical modelling via regression or mixed effects modelling.

A statistical model generally takes the following form as an equation:

$$(a*z) + (b*y) + (c*x) + (d*w) = \text{Output} + \text{Error Term} \qquad (1)$$

In this example there are four factors (a,b,c,d) with four associated weightings (w,x,y,z). These are combined to create an output with a certain amount of possible variability described by the error term. Thus, if we are able to provide a quantified impression of the role of certain factors, we can predict how these factors will combine to produce a certain outcome to a certain degree of accuracy.

In terms of the trait analysis of the present study, if we were to have a female participant, aged 35, who travelled alone and had no previous experience of cruise ships, it would be possible to predict the quantitative value of her evacuation. This could then be compared with an optimal evacuation procedure to assess the efficiency of the participant's route or strategy. Furthermore, if we apply certain differences that were evidenced in the present study, it would be possible to further improve the efficacy of evacuation. It was noted that females tend to undertake more information-seeking activities. It was also noted that younger sub-cohorts displayed a tendency to not follow instructions. Thus, in an extreme example, if there were to be a cruise ship populated entirely with young females, evacuation would be improved through the authoritative communication of clear, complete instructions with an emphasis on the importance of following these instructions.

The ultimate aim of psychological evacuation research is the production of a decision-making model which is compatible with computational action models. Statistical modelling is the ideal form for this research to create. Unfortunately, the current methodology surrounding behavioural sequence analysis is not directed towards this goal. However, it is possible to redirect research towards this goal through maximising efforts towards the collection, creation, and interpretation of quantitative results.

7.5 Conclusions

Legal and remembered accounts and guided and imagined accounts all have flaws. A more purposeful method for data collection is structured and interactive accounts. The researcher is able to create the exact story to be told and the number, quality, and types of decisions between which the participant must choose. It is also possible to include questions concerning the motivations of the participant. Such a new structure allows the researcher to control the precise nature of the examination. Furthermore, the introduction of quantitative values to choices, transitions and entire sequences creates a better quality of data, which in turn enables more rigorous and appropriate analysis. These variables may be experimentally manipulated or improved through replication. Finally, the role of traits of participants may be properly evaluated and included as factors with appropriate weightings in the form of a computational model. The methodological improvements suggested have the capability to redirect psychological examination towards the desired outputs. Models require objective, quantitative valuations. For psychological investigation of decision-making in emergency scenarios to progress, the focus must become these quantitative valuations.

Chapter Eight: Conclusions

This thesis provided a thorough analysis of the behaviours apparent in a real-life maritime disaster evacuation. This was then compared to accounts provided by participants imagining themselves to be in a similar situation. This comparison was intended as a test of the validity of the potentially valuable methodology available via the talk-through method of data collection. Preliminary results were encouraging. A generalised taxonomy of acts was sufficient to describe progression through both real-life and imagined accounts of evacuation. When compared collectively, the number of acts and transitions between acts were demonstrated to be highly correlated. This finding is a novel contribution which provides evidence for the ecological validity of the talk-through method of data collection. However, as progression was made through deeper levels of analysis, flaws in both the talk-through method and behavioural sequence analysis became increasingly apparent. Consequently, a new methodology for data collection and data capture was proposed in order to redirect future research towards producing appropriate outputs and finally focusing on the psychological aspects of evacuation which require examination.

The present thesis outlines a taxonomy of acts, which seems capable of describing sequences of maritime evacuations. These acts are apparent in reports of different samples of real-life emergencies and in reports of imagined emergencies. It seems reasonable to consider this taxonomy to be the basis for an act-based behavioural model. Future research may refine and develop this model towards a sequence-based behavioural model. Such a model could then be integrated with a computational model concerning speed, direction, and other physical factors to create a combined model of evacuation. Once such a model is available, it may be used to guide and inform safety procedures on maritime vessels. In the modern world, cruise ships are able to carry thousands of passengers. Although maritime disasters are relatively infrequent, when they do occur, they can be devastating. Therefore, this area of research is very important with regards to preventing unnecessary and extreme loss of life.

Another novel contribution of this thesis was the detection of differences between the acts and transitions reported by real-life versus imagined cohorts. Further differences were detected when the entire cohorts were divided into categories based on traits including gender, age, companions, and experience. However, in order to more accurately quantify such differences, any acts or transitions need to be considered in terms of their position within a complete sequence. As research and analysis progressed during this thesis it became more apparent that the methodologies available were not correctly oriented towards providing the required answers to the essential questions. To understand decision making it is necessary to understand what motivates people to make a certain choice when confronted with multiple possible actions or sequences of actions. With evacuation scenarios providing an environment where the understanding of risk is vital, it is perhaps the responsibility of further research in this area to fill the gaps in current knowledge.

Human decision-making is a complex phenomenon. If this decision-making is required in a situation not previously experienced which may become life-threatening, the complexity is compounded by a multitude of variables and potential interactions. In order to attempt to model this complexity, there needs to be a greater appreciation of potential inputs and how they affect a quantifiable output. In the present study, traits were used to breakdown the results of an entire cohort. In modelling terms, any trait would be considered an input which creates the results of an entire cohort. . Further research in this field should focus on the influence of traits on evacuation strategy.

The ultimate recommendation of this research is that examination of evacuation behaviour needs to be focused on answering the correct psychological questions in a manner capable of being modelled. This thesis utilized the current best method for the sequential analysis of verbal reports. It provided evidence for a list of general acts sufficient for explaining an evacuation sequence. It also provided evidence for the ecological validity of the talk-through method of data collection. Furthermore, it provided evidence for certain traits influencing sequences of acts. However, this current method is unable to pinpoint the importance, or value, of a transition towards successful evacuation. Therefore, a new methodology was proposed which changes several focuses, which it is hoped will improve future research. It is necessary to allow the researcher to become the storyteller. In this way, the researcher controls the precise area and granularity with which it is explored. Then it is only the responsibility of the participant to make the choices and, perhaps, finally provide explanations for their motivations. The story told can involve many decisions of different types with different consequences, but all are quantifiable and may be experimentally manipulated if required. The final quantified output serves as a descriptive sum of the multitude of possible variables, which may act as inputs. By focusing on the correct questions and providing answers in the correct format, the recommended new methodology should promote progress in the field of evacuation research.

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Appendix I

Consent form and information sheet provided to participants.

CONSENT FORM

Understanding and predicting human behaviour in maritime emergencies.

It is important that you read, understand and sign the consent form. Your contribution to this research is entirely voluntary and you are not obliged in any way to participate, if you require any further details please contact your researcher.

I have been fully informed of the nature and aims of this study as outlined in the information sheet version 2, dated 21:03:2019	□
I consent to taking part in this the study	□
I understand the possible disadvantages and risks of taking part in this study	
I understand that I have the right to withdraw from the study at any time during and following the interview.	□
I give permission for my words to be quoted (by use of pseudonym)	□

I give permission to the researcher to audio-record our meeting	
I understand that the information collected will be kept in secure conditions for a period of 2 years by the researcher.	□
I understand that no person other than the researcher/s and facilitator/s will have access to the information provided	□
I understand that my identity will be protected by the use of pseudonym in any report, at conferences, or in published articles.	□

If you are satisfied that you understand the information and are happy to take part in this project please put a tick in the box aligned to each sentence and print and sign below.

Signature of Participant: ______________________	Signature of Researcher: ______________________
Print: ______________________	Print: ______________________
Date: ______________________	Date: ______________________

(one copy to be retained by Participant / one copy to be retained by Researcher)

Understanding and Predicting Human Behaviour in Maritime Emergencies.

INFORMATION SHEET

You are being invited to take part in a study about human behaviour in emergency situations. Before you decide to take part it is important that you understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it me if you wish. Please do not hesitate to ask if there is anything that is not clear or if you would like more information.

Location of the study:

The study will take place at the Facolta di Medicina, Dipartimento di Neurologia e Psichiatria, Universita degli Studi di Roma, La Sapienza.

What is the study about?

The purpose of this study is to investigate human behaviour during emergencies. The aim of the project is to investigate differences between predicted and actual behaviour in emergency situations. To compare results of two different approaches: The use of reports by survivors and the use of participant predictions as approaches for predicting human behaviour in emergency scenarios. Ultimately the aims lead to the intended outcome of developing recommendations and guidance for human factors professionals responsible for behavioural predictions in emergency situations.

Can I take part in the study?

- Aged 25-80 years old
- You (or any close relatives) have never been involved in a maritime emergency
- You are not suffering from mental health issues (such as anxiety, panic attacks, depression, PTSD, etc.)

Do I have to take part?

It is your decision whether or not you take part. If you decide to take part you will be asked to sign a consent form, and you will be free to withdraw without giving a reason.

What will I need to do?

If you agree to take part in the research you will be asked to meet with one of our research workers for an interview. It will take a maximum of one hour to complete the interview. Breaks will be available as needed at any point during the session.

The interview will consist in the researcher describing a hypothetical scenario to you and asking you to describe what you think you would do in said scenario. You will have the chance to review your predicted behaviours.

With your permission, we would like to audio-record the meeting so that we may be able to rate the consistency of scoring between our different researchers.

What are the possible benefits of taking part?

There are no specific direct benefits in taking part, however this study may be beneficial by ultimately helping improve emergency plans and procedures.

What are the possible disadvantages and risks of taking part?

The interview covers issues that may be sensitive and/or distressing for you, such as discussing stressful/traumatic scenarios and events. You can stop at any stage of the interview if you feel uncomfortable. In case of feelings of discomfort, distress or any other negative feelings you are invited to contact the free counselling center by email at ***unicounseling@gmail.com*** or **counselling.psicologico@laziodisu.it** and by phone at 0633775363 (Mon-Fri, 10am to 5pm).

Will my identity be disclosed?

Your identity will not be disclosed. All information disclosed within the interview will be kept confidential.

What will happen to the information?

All information collected from you during this research will be kept secure and moved to be stored securely on The University of Huddersfield's mainframe as soon as possible following data collection. Anonymity will be ensured by the use of participant numbers, names will not be stored alongside their data or participant number. It is anticipated that the research may, at some point, be published in a journal or report. However, should this happen, your anonymity will be ensured, although it may be necessary to use your words in the presentation of the findings and your permission for this is included in the consent form.

Can I change my mind?

If at any point you wish to withdraw from the interview, you may do so without providing a reason.

You have the right to withdraw from the study at any time by email providing your participant number and the name of study.

Who has ethically reviewed the project?

The project has been ethically approved by the School Ethics Research Panel (SREP) of the School of Human and Health Sciences, University of Huddersfield.

Who can I contact for further information?

If you require any further information about the research, please contact me on:

Name Otero Finiti

E-mail **otero.finiti@hud.ac.uk**

Thank you for taking part in this research.